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MONTHLY WEATHER REVIEW

Editor, EDGAR W. WOOLARD

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A BRIEF LIST OF WORKS ON METEOROLOGY

Compiled by Richmond T. Zoch

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FIGURE 1.

FIGURE 2.

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AN OBSERVATION OF ANTICREPUSCULAR RAYS

By JOHN G. ALBRIGHT

[Case School of Applied Science, Cleveland, Ohio, October 1936]

On the evening of September 14, 1936, the writer had the privilege of observing, near Mount Sterling, Ohio, an unusual phenomenon in connection with sunset. About 5 minutes after sunset, pale yellowish bands across the sky were noticed, which seemed to converge at a point opposite to the setting sun. In general appearance, the sky was clear overhead and in the east; there was, however, a slight haze in the upper atmosphere. A few clouds were visible on the western horizon in the direction of the sun, but the bands were not noticeable in that direction. In the eastern sky the bands were quite distinct and lasted for about 15 minutes. At first sight, the impression was conveyed that the sun was in the east and was in some manner obscured just above the horizon.

Fortunately, a camera, equipped with an orange filter, which the writer had been using to photograph cloud formations, was at hand and two pictures were obtained at an interval of about 5 minutes. Careful examination will disclose that the point of convergence in figure 1 is near the top of the small tree which stands between the house and the barn; figure 2, which was taken about 5 minutes later, shows the point of convergence slightly above the tree.

These bands were the anticrepuscular rays caused by the scattering of sunlight in the upper atmosphere, the dark streaks being the parts shaded by the clouds on the western horizon.[1] Since the rays of the sun which enter the earth's atmosphere are practically parallel, the point of apparent convergence of the bands is merely the "vanishing point" for the parallel bands formed by the sun's rays. It follows, then, that the sun, the observer, and the point of apparent convergence are in the same straight line, and that this point of apparent convergence is the antisolar point. Since the sun had already set, the point of apparent convergence was above the horizon as shown in both photographs.

[1] W. J. Humphreys, *Physics of the Air*, 2 ed., p. 434.

THE GEOMETRICAL THEORY OF HALOS—II [1]

By EDGAR W. WOOLARD

[Weather Bureau, Washington, D. C., January 1937]

PART 1. THE FUNDAMENTAL OPTICAL EQUATIONS

For completeness, the discussion will include a concise summary of the fundamental elementary optical laws upon which the calculations in the theory of halos must be based; their derivations will be found in standard treatises on optics or in other works to which reference will be made.

The only physical principles that are required in the purely geometrical problem of calculating the optical meteors that may be produced by crystals of a given form in a given orientation are the laws of simple refraction and simple reflection:

(1) In *simple refraction*, the incident and the refracted rays lie in the same plane with the normal at the point of incidence, while the sines of the angles of incidence and of refraction bear a constant ratio to one another:

$$\sin i=\mu \sin r.$$

The constant μ is the index of refraction; if $\mu>1$, the ray is turned toward the normal, otherwise away from the normal; only the former case need be considered, since the same computations may be applied when $\mu<1$ by interchanging the incident and the refracted rays (if $\sin r$ becomes greater than unity, total internal reflection is indicated).

(2) When light is *regularly reflected* at an interface, externally or internally, the reflected ray lies in the plane through the incident ray and the normal to the interface at the point of incidence; the angle of incidence is equal to the angle of reflection:

$$i=R.$$

In both cases, the *deviation* of the ray, or angle through which it is turned from its original direction, is the angular displacement of the virtual image from the true position of an infinitely distant source.

REFRACTION

An application of the law of refraction (fig. 1) at both the point of incidence and the point of emergence of a ray which traverses a prism gives the laws of prismatic refraction:

Prismatic refraction in a principal plane.—Consider first the case when *the incident ray lies in the principal plane* of a refracting dihedral angle, i. e., in the plane perpendicular to the refracting edge of the prism; the entire course of the ray is then in this plane. The general character of the path that will be followed at any given angle of incidence, figure 2, depends upon the relation between the value of the refracting angle α and the maximum possible value of the angle of refraction (critical angle) $\gamma=\arcsin(1/\mu)$; in the discussion of halos, it is usual to adopt $\mu=1.31$ (the refractive index of ice for the yellow-green), whence $\gamma=49°45'40''$, and no light will be transmitted through two crystal faces inclined 99°31′ or more to each other. E. g., adjacent faces of a hexagonal prism do not constitute a refracting angle, but alternate faces form a truncated refracting angle of 60°. For the ultimate purpose of the present discussion, the best representation of the geometric relations involved is obtained by conceiving the prism to be placed at the center of a sphere of indefinitely great radius, to which all the lines and planes are extended, and then working with the resulting points and arcs on the sphere by means of spherical trigonometry, figures 2 and 3. With appropriate conventions of algebraic sign for the angles, as indicated in figure 2, the position of the image will in all cases be automatically given by the same set of formulae, figure 3; i is to be considered negative when the incident ray lies between the normal

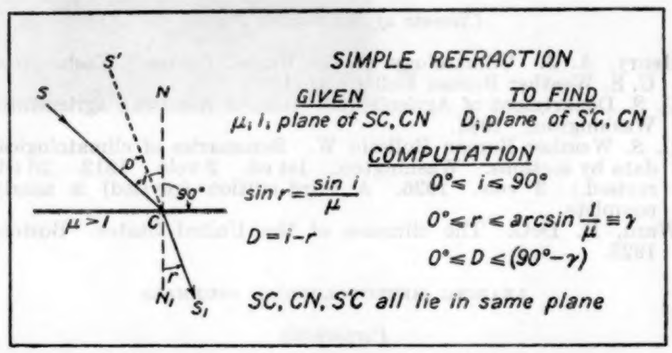


FIGURE 1. *Simple refraction.*—S, luminous source; SC, incident ray, lying in the optically rarer medium; CN, normal to interface at point of incidence; i, angle of incidence; CS_1, refracted ray; r, angle of refraction; S′, virtual image; D, deviation.

and the vertex, and a negative i' is to be interpreted as indicating a similar location for the emergent ray. As i varies between its extreme possible limits, the deviation D, or angular displacement of the image from the infinitely distant source, varies from a minimum

$$D_0=2\arcsin\left(\mu\sin\frac{\alpha}{2}\right)-\alpha$$

at

$$\begin{cases} i=i'=\arcsin\left(\mu\sin\dfrac{\alpha}{2}\right)=\dfrac{1}{2}(D_0+\alpha), \\ r=r'=\alpha/2, \end{cases}$$

to a maximum

$$D_m=180°-\{\alpha+\text{arc}\cos[\mu\sin(\alpha-\gamma)]\}$$

at both $i=90°$ and $i'=90°$. The deviation of the image is always toward the position of the vertex of the refracting angle, V, which is 90° from N, in the plane of the face of incidence.

[1] For paper I, a general introductory discussion, see MON. WEATHER REV., 64:321-325, 1936.

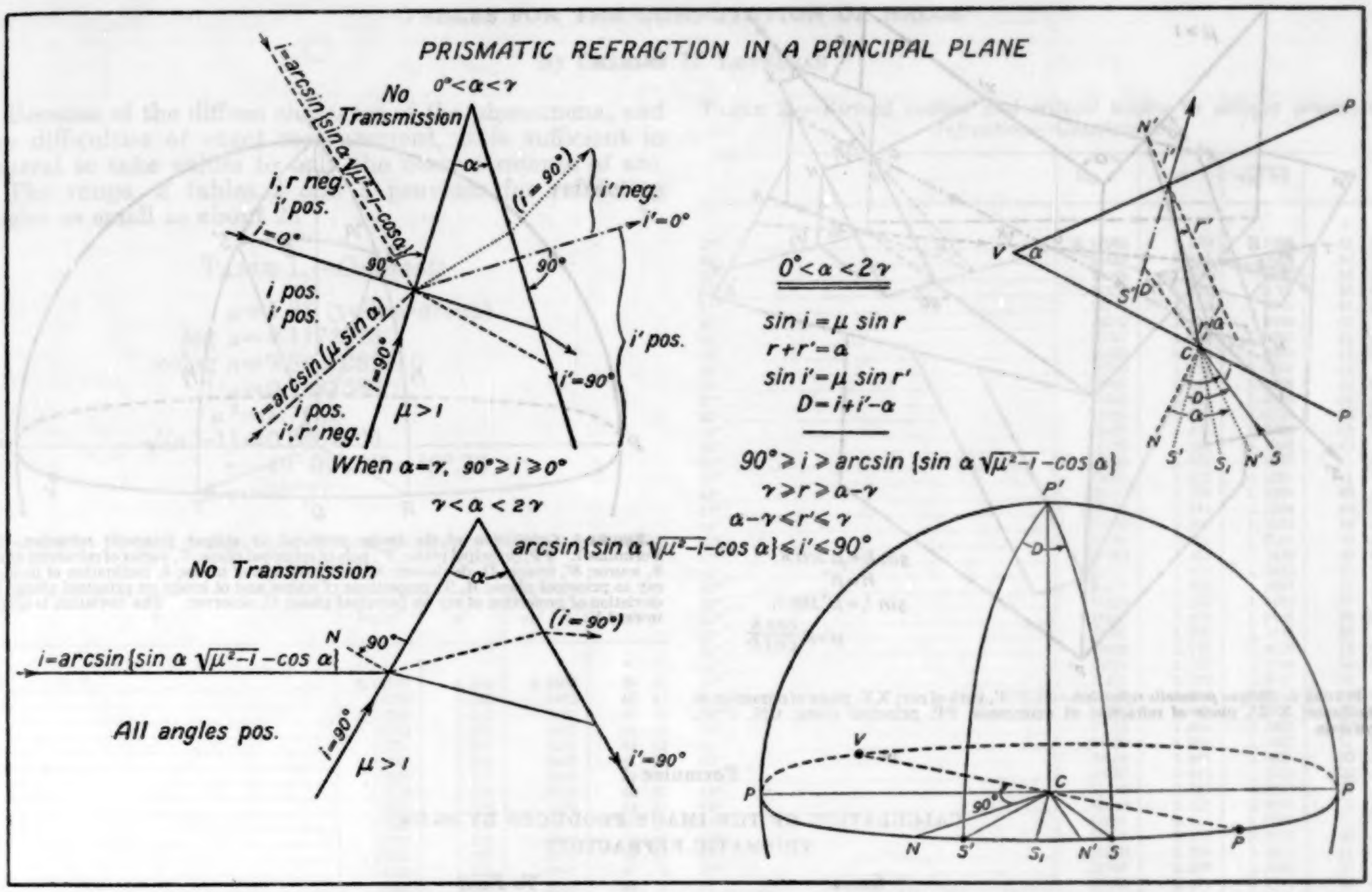
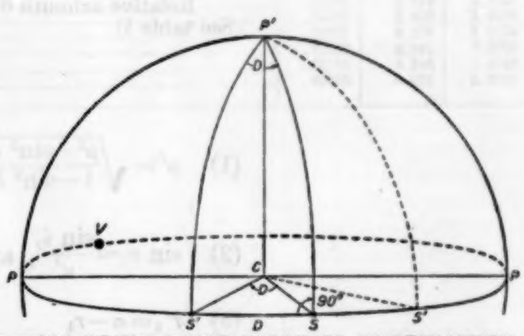


FIGURE 2. *Prismatic refraction in a principal plane.*—PP, principal plane; V, vertex of refracting angle α; VCP, face of incidence; P', pole of principal plane; N, N', normals at points of incidence and of emergence, respectively; CS_1, internal ray. The deviation, D, is always toward the vertex.

Oblique prismatic refraction.—Now consider the case when *the incident ray is inclined* at an angle h to the principal plane, figure 4. It may be shown to follow from the law of refraction [2] that the emergent ray is inclined at the same angle, h, to the principal plane; and that the projection of the course of the ray onto the principal plane is exactly the path that would be followed by an actual ray in this plane if the index of refraction were $\mu \dfrac{\cos k}{\cos h}$, where k is given by $\sin h = \mu \sin k$ and is the inclination of the internal ray to the principal plane. These relations are known as Bravais' Laws; and, with the preceding formulae for refraction in a principal plane, they provide means for the trigonometric calculation of the image produced by oblique prismatic refraction (fig. 5 and formulae I).

Because of the limitation which internal reflection puts on the angle of incidence in the principal plane, there is a limit to h beyond which no transmission takes place; in the case of a 60° refracting angle, e. g., h cannot exceed 60°45'. The deviation D is always less than D'; the minimum of D is at that of D', and the least minimum or *minimum minimorum* occurs when the ray traverses a symmetrical path in the principal plane. Only α, D, D' may exceed 90°. The deviation D' is always toward the position of the vertex, V, 90° from N, in the plane of the face of incidence. Several tables which facilitate computations with the preceding formulas accompany this paper.

[2] W. J. Humphreys, *Physics of the Air*, 2 ed., New York, 1929, pp. 486–490. H. S. Uhler, *Amer. Math. Monthly*, 28: 1–10, 1921, *Amer. Jour. Sci.*, (4), 35: 389–423, 1913, and *Jour. Opt. Soc. Amer.*, 26: 89–90, 1936. *Cf.* L. Silberstein, Vectorial Treatment of Refraction of Skew Rays by a Prism, *Jour. Opt. Soc. Amer. and R. S. I*, 16: 88–91, 1928; and M. Szulc, *Acta Physica Polonica*, 3: 115–121, 1934. The papers by Uhler form an especially complete and valuable discussion of prismatic refraction.



CALCULATION OF THE IMAGE PRODUCED BY REFRACTION IN THE PRINCIPAL PLANE OF A DIHEDRAL ANGLE

GIVEN	TO FIND
μ, α, i Coordinates of S in Principal Plane System: Altitude 0° Relative Azimuth 0°	Coordinates of S': In Principal Plane System— Altitude 0° Relative Azimuth ±D S' Relative to S— Deviation D Position Angle ±90°

COMPUTATION

$\arcsin\{\sin\alpha\sqrt{\mu^2-1}-\cos\alpha\}\leq i\leq 90°$

$\sin r = \dfrac{\sin i}{\mu}$

$r' = \alpha - r$

$\sin i' = \mu \sin r'$

$D = i + i' - \alpha$

FIGURE 3. *Calculation of the image produced by refraction in the principal plane of a dihedral angle.*—PP, principal plane; P', pole of principal plane; V, vertex of refracting angle; S, source; S', image; D, deviation; C, observer.

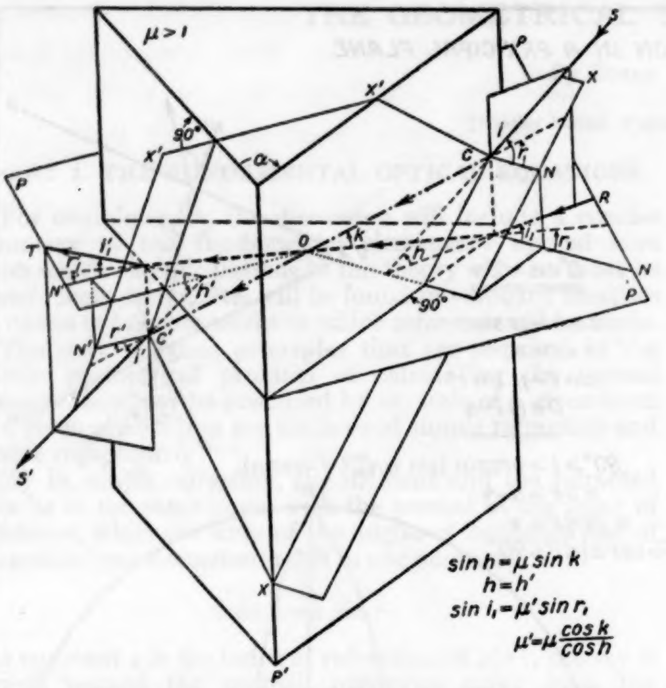


FIGURE 4. *Oblique prismatic refraction.*—SCC'S', path of ray; XX, plane of refraction at incidence; X'X', plane of refraction at emergence; PP, principal plane; CN, C'N', normals.

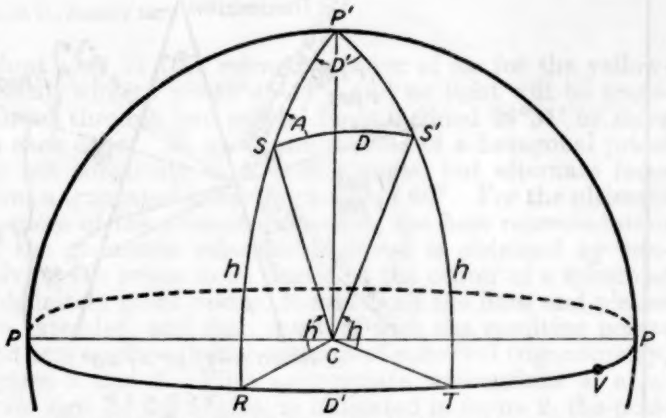


FIGURE 5. *Calculation of the image produced by oblique prismatic refraction.*—See Formulae I. PP, principal plane; P', pole of principal plane; V, vertex of refracting angle; S, source; S', image; D, deviation; A, position angle of image; *h*, inclination of incident ray to principal plane; R, T, projections of source and of image on principal plane; D', deviation of projection of ray on principal plane; C, observer. The deviation is always toward V.

Formulae I

CALCULATION OF THE IMAGE PRODUCED BY SKEW PRISMATIC REFRACTION

Given	*To Find*
μ, α; h, i_1.	Coordinates of S'
Coordinates of S:	Principal plane system:
Principal plane system:	Altitude h
Altitude h	Relative azimuth ±D'
Relative azimuth 0°	Relative to S
(See table 1)	Deviation D
	Position angle ±A

Computation

(1) $\mu' = \sqrt{\frac{\mu^2 - \sin^2 h}{1 - \sin^2 h}}$, $0^0 \leq h \leq \text{arc cos}\left\{\sqrt{\mu^2 - 1}\tan\frac{\alpha}{2}\right\}$ (Table 2)

(2) $\sin r_1 = \frac{\sin i_1}{\mu'}$, $\arcsin\{\sin\alpha\sqrt{\mu'^2 - 1} - \cos\alpha\} \leq i_1 \leq 90^\circ$ (Table 3)

(3) $r'_1 = \alpha - r_1$

(4) $\sin i'_1 = \mu' \sin r'_1$ (Table 3)

(5) $D' = i_1 + i'_1 - \alpha$ toward position of vertex

(6) $D = 2\ \text{arc sin}\{\sin\frac{1}{2}D' \cos h\}$, $D < D'$

(7) $A = \text{arc cot}\{\tan\frac{1}{2}D' \sin h\}$

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(8) $D'_0 = 2\ \text{arc sin}\left\{\mu' \sin\frac{\alpha}{2}\right\} - \alpha$ at $i_1 = \frac{1}{2}(D'_0 + \alpha)$

(9) $D'_m = 180^\circ - \left\{\alpha + \text{arc cos}\left[\mu' \sin\left(\alpha - \text{arc sin}\frac{1}{\mu'}\right)\right]\right\}$ at $i_1 = 90^\circ$

[See fig. 5. The first 5 formulae follow from Bravais' laws; and the next two from the solution of the right spherical triangle formed by dropping a perpendicular from the vertex *P'* of the isosceles triangle *P'SS'*.]

TABLES FOR THE COMPUTATION OF HALOS

By CHARLES M. LENNAHAN

Because of the diffuse character of the phenomena, and the difficulties of exact measurement, it is sufficient in general to take values to only the nearest minute of arc. The range of tables 2 and 3 provides for refracting angles as small as about 23°.

TABLE 1.—*Constants*

$$\mu=1.31 \text{ (yellow-green)}$$
$$\log \mu=0.1172713$$
$$\text{colog } \mu=9.8827287\text{–}10$$
$$1/\mu=0.7633588$$
$$\mu^2=1.7161$$
$$\sqrt{(\mu^2-1)}=0.8462269$$
$$\gamma=49°45'40''=49°.76$$
$$2\gamma=99°31'$$

TABLE 2.—*Virtual indices and critical angles in oblique prismatic refraction*

h	$\log \mu'$	μ'	$\sqrt{\mu'^2-1}$	γ'	
				°	′
0°	0.11727	1.310	0.8462	49	46
1°	.11730	1.310	.8462	49	45
2°	.11737	1.310	.8462	49	45
3°	.11753	1.311	.8478	49	43
4°	.11771	1.311	.8478	49	42
5°	.11797	1.312	.8493	49	39
6°	.11827	1.313	.8509	49	36
7°	.11864	1.314	.8524	49	33
8°	.11905	1.315	.8539	49	29
9°	.11952	1.317	.8570	49	25
10°	.12007	1.318	.8586	49	20
11°	.12065	1.320	.8616	49	14
12°	.12133	1.322	.8647	49	8
13°	.12206	1.325	.8693	49	1
14°	.12282	1.327	.8723	48	55
15°	.12368	1.329	.8754	48	47
16°	.12459	1.332	.8799	48	39
17°	.12557	1.335	.8844	48	30
18°	.12662	1.338	.8890	48	20
19°	.12777	1.342	.8950	48	10
20°	.12895	1.346	.9010	48	0
21°	.13021	1.350	.9069	47	49
22°	.13157	1.354	.9129	47	37
23°	.13302	1.358	.9188	47	24
24°	.13454	1.363	.9262	47	11
25°	.13614	1.368	.9335	46	58
26°	.13782	1.374	.9423	46	44

TABLE 2.—*Virtual indices and critical angles in oblique prismatic refraction*—Continued

h	$\log \mu'$	μ'	$\sqrt{\mu'^2-1}$	γ'	
				°	′
27°	0.13963	1.379	0.9496	46	28
28°	.14149	1.385	.9582	46	13
29°	.14348	1.392	.9683	45	57
30°	.14556	1.398	.9769	45	40
31°	.14774	1.405	.9869	45	22
32°	.15003	1.413	.9983	45	4
33°	.15247	1.421	1.0096	44	45
34°	.15503	1.429	1.0208	44	25
35°	.15769	1.438	1.0334	44	4
36°	.16047	1.447	1.0458	43	43
37°	.16342	1.457	1.0596	43	21
38°	.16654	1.467	1.0734	42	58
39°	.16977	1.478	1.0883	42	34
40°	.17322	1.490	1.1046	42	9
41°	.17680	1.502	1.1207	41	44
42°	.18055	1.515	1.1381	41	17
43°	.18452	1.529	1.1566	40	50
44°	.18868	1.544	1.1764	40	22
45°	.19300	1.560	1.1973	39	53
46°	.19761	1.576	1.2181	39	23
47°	.20240	1.593	1.2400	38	52
48°	.20741	1.612	1.2643	38	20
49°	.21272	1.632	1.2897	37	47
50°	.21835	1.653	1.3162	37	13
51°	.22423	1.676	1.3450	36	38
52°	.23037	1.700	1.3748	36	2
53°	.23689	1.725	1.4056	35	25
54°	.24379	1.753	1.4398	34	47
55°	.25101	1.782	1.4750	34	8
56°	.25857	1.814	1.5135	33	28
57°	.26668	1.848	1.5541	32	46
58°	.27518	1.884	1.5967	32	3
59°	.28409	1.924	1.6437	31	19
60°	.29354	1.966	1.6927	30	35
61°	.30357	2.012	1.7459	29	48
62°	.31410	2.061	1.8021	29	1
63°	.32540	2.115	1.8636	28	13
64°	.33731	2.174	1.9304	27	23
65°	.34983	2.238	2.0022	26	33
66°	.36330	2.308	2.0801	25	40
67°	.37764	2.386	2.1663	24	47
68°	.39280	2.471	2.2596	23	53
69°	.40809	2.564	2.3610	22	57
70°	.42630	2.669	2.4746	22	0
71°	.44483	2.785	2.5993	21	3
72°	.46470	2.915	2.7381	20	4
73°	.48606	3.062	2.8841	19	4
74°	.50908	3.229	3.0703	18	2
75°	.53395	3.419	3.2695	17	0
76°	.56092	3.638	3.4978	15	57
77°	.59027	3.893	3.7624	14	53
78°	.62236	4.191	4.0700	13	48
79°	.65765	4.546	4.4346	12	42
80°	.69686	4.976	4.8745	11	36

TABLE 3.—*Law of Refraction*, $\mu=1.31$

i \ r	h=0°		5°		10°		15°		20°		25°		30°		35°		40°		45°		50°		55°		60°		65°		70°		75°		80°	
	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'
90°	49	46	49	39	49	20	48	47	48	00	46	58	45	40	44	04	42	09	39	53	37	13	34	08	30	35	26	33	22	00	17	00	11	36
89°		45		38		19		46	47	59		57		39		04		09		52		13		07		34		32	22	00	17	00		36
88°		43		37		17		44		58		56		38		02		07		51		12		06		33		31	22	00	17	00		35
87°		40		34		14		41		55		53		35	44	00		05		49		10		04		32		30	21	59	16	59		35
86°		36		29		10		37		50		49		31	43	56		02		46		07		02		30		28		57		58		34
85°		30		24		05		32		45		44		26		51	41	57		42		03	33	59		27		26		55		57		33
84°		23		17	48	58		25		39		38		20		46		52		37	36	59		55		24		23		53		55		32
83°		15		09		50		18		31		30		14		39		46		32		54		50		20		20		50		52		30
82°		06	49	00		41		09		23		22		06		32		39		25		48		45		15		16		47		50		29
81°	48	56	48	50		31	47	59		13		13	44	57		23		31		18		41		39		10		11		43		47		27
80°		44		38		20		48		02		02		47		14		22		10		34		32		04		06		39		44		25
79°		32		26		07		36	46	50	45	50		36		04		12		01		25		25	29	57		01		35		41		23
78°		18		12	47	54		22		37		38		24	42	52		02	38	51		16		17		50	25	55		30		37		20
77°		03	47	57		39		08		23		25		11		40	40	50		40		07		08		43		49		25		33		18
76°	47	47		41		23	46	52		08		10	43	57		27		38		28	35	56	32	59		35		42		19		29		15
75°		30		24		06		36	45	52	44	55		42		12		24		16		45		40		26		34		13		25		12
74°		12		06	46	49		18		35		38		26	41	57		10		03		33		38		17		26		07		20		08
73°	46	53	46	48		30	46	00		17		21		09		42	39	55	37	49		20		27		07		18	21	00		14		05
72°		33		28		10	45	40	44	58		02	42	52		25		40		35		07		15	28	56		09	20	53		09		01
71°		12		07	45	49		20		38	43	43		33		07		23		19	34	53		02		45	25	00		45		03	10	57
70°	45	50	45	45		28	44	59		17		23		14	40	49		06		03		38	31	49		33	24	50		37	15	57		53
69°		27		22		05		36	43	56		02	41	53		29	38	48	36	46		23		35		21		39		29		51		49
68°		03	44	58	44	41		13		33	42	40		32		09		29		29		07		21		09		28		20		44		44
67°	44	38		33		17	43	49		10		17		11	39	49		09		10	33	50		06	27	56		17		11		37		40
66°		13		08	43	52		24	42	45	41	53	40	48		27	37	49	35	51		33	30	50		42		06		01		30		35
65°	43	47	43	41		26	42	59		20		29		24		05		28		32		15		34		27	23	54	19	51		22		30
64°		19		14	42	59		32	41	55		04	40	00	38	42		06		12	32	56		17		12		41		41		14	10	24
63°	42	51	42	46		31		05		28	40	38	39	35		18	36	43	34	51		37	30	00	26	57		28		30		06		--------
62°		23		18		03	41	37	41	00		11		10	37	53		20		29		17	29	42		41		14		19	14	58		--------
61°	41	53	41	48	41	34		08	40	32	39	44	38	43		28	35	56		07	31	56		23		25	23	00		08		49		--------
60°		23		18		04	40	39		03		16		16		02		32	33	44		35		04		08	22	46	18	56		40		--------
59°	40	52	40	48	40	33		09	39	34	38	48	37	49	36	36		07		20		14	28	45	25	51		31		44		31		--------
58°		20		16		02	39	38		04		18		20		09	34	41	32	56	30	52		25		33		16		32		22		--------
57°	39	48	39	44	39	30		07	38	33	37	48	36	51	35	41		15		32		29		04		15		01		19		12		--------
56°		16		11	38	58	38	35		02		18		22		13	33	48		07		06	27	43	24	57	21	45		06		02		--------
55°	38	42	38	38		25		02	37	30	36	47	35	52	34	44		21	31	41	29	42		22		38		28	17	53	13	52		--------
54°		08		04	37	51	37	29	36	57		15		21		15	32	53		15		18	27	00		18		12		39		41		--------
53°	37	34	37	30		17	36	55		24	35	43	34	50	33	45		25	30	48	28	53	26	37	23	58	20	55		25		30		--------
52°	36	59	36	55	36	42		21	35	51		10		18		14	31	56		21		28		14		38		37		10		19		--------
51°		23		19		07	35	46		16	34	37	33	46	32	43		26	29	53		02	25	51		17		19	16	56		08		--------
50°	35	47	35	43	35	31		11	34	41		03		13		12	30	56		25	27	36		27	22	56		01		41	12	57		--------
49°		11		07	34	55	34	35		06	33	29	32	40	31	40		26	28	56		10		03		35	19	43		26		45		--------
48°	34	34	34	30		19	33	59	33	31	32	54		06		08	29	55		27	26	43	24	38		13		24		10		33		--------
47°	33	56	33	53	33	41		22	32	55		19	31	32	30	35		24	27	58		15		13	21	50		05	15	54		21		--------
46°		18		15		04	32	45		19	31	43	30	58		01	28	52		28	25	47	23	48		28	18	46		38		09		--------
45°	32	40	32	37	32	26		08	31	42		07		23	29	27		20	26	58		19		22		05		25		22	11	56		--------
44°		01	31	58	31	48	31	30		05	30	31	29	47	28	53	27	47		27	24	51	22	56	20	42		05		05		43		--------
43°	31	22		19		09	30	52	30	27	29	54		12		19		14	25	56		22		30		18	17	45	14	48		30		--------
42°	30	43	30	40	30	30		13	29	49		17	28	36	27	44	26	41		24	23	52		03	19	54		24		31		17		--------
41°		03	30	00	29	50	29	34		11	28	39	27	59		09		07	24	52		23	21	36		30		03		14		04		--------
40°	20	23	29	20		11	28	55	28	32		01		22	26	33	25	33		20	22	53		08		05	16	42	13	56	10	50		--------
39°	28	43	28	40	28	31		15	27	53	27	23	26	45	25	57	24	59	23	48		22	20	41	18	40		20		38		36		--------
38°		02	27	59	27	50	27	35		14	26	45		07		21		24		15	21	52		13		15	15	58		20		22		--------
37°	27	21		18		10	26	55	26	34		06	25	30	24	45	23	49	22	42		21	19	44	17	50		36		02		08		--------
36°	26	40	26	37	26	29		14	25	54	25	27	24	52		08		14		08	20	50		15		24		14	12	43	9	54		--------
35°	25	58	25	55	25	47	25	33		14	24	47		13	23	31	22	38	21	35		18	18	46	16	58	14	51		25		39		--------
34°		16		14		06	24	52	24	33		07	23	34	22	53		02		01	19	46		17		32		28		06		25		--------
33°	24	34	24	32	24	24		11	23	52	23	27	22	55		16	21	26	20	26		14	17	48		05		05	11	47		10		--------
32°	23	52	23	49	23	42	23	29		11	22	47		16	21	38	20	50	19	52	18	42		18	15	38	13	42		27	8	55		--------
31°		09		07	23	00	22	47	22	30		07	21	37	20	59		13		17		09	16	48		11		18		08		40		--------
30°	22	26	22	24	22	17		05	21	49	21	26	20	57		21	19	36	18	42	17	36		17	14	44	12	55	10	48		25		--------
29°	21	43	21	41	21	34	21	23		07	20	45		17	19	42	18	59		07		03	15	47		17		31		28		09		--------
28°	21	00	20	58	20	51	20	41	20	25		04	19	37		03		22	17	31	16	30		16	13	49		07		08	7	53		--------
27°	20	16		15		08	19	58	19	43	19	23	18	57	18	24	17	44	16	55	15	56	14	45		21	11	42	9	48		38		--------
26°	19	33	19	31	19	25		15		01	18	41		16	17	45		07		19		23		14	12	53		18		27		22		--------
25°	18	49	18	47	18	42	18	32	18	18	18	00	17	36		06	16	29	15	43	14	49	13	43		25	10	53		07		06		--------
24°		05		03	17	58	17	49	17	35	17	18	16	55	16	26	15	50		07		14		11	11	56		28	8	46	6	50		--------
23°	17	21	17	19		14		06	16	53	16	36		14	15	46		12	14	31	13	40	12	40		28		03		25		34		--------
22°	16	37	16	35	16	30	16	22		10	15	53	15	32		06	14	34	13	54		06		08	10	59	9	38		04		17		--------
21°	15	53	15	51	15	46	15	38	15	27		11	14	51	14	26	13	55		17	12	31	11	36		30		13	7	43		01		--------
20°		08		07		02	14	54	14	43	14	29		10	13	46		16	12	40	11	56		04		01	8	47		22	5	44		--------
19°	14	23	14	22	14	18		10	14	00	13	46	13	28		05	12	37		03		21	10	32	9	32		22	7	00		28		--------
18°	13	39	13	37	13	33	13	26	13	17		03	12	46	12	25	11	58	11	26	10	46	9	59		03	7	56	6	39		11		--------
17°	12	54	12	53	12	49	12	42	12	33	12	20		04	11	44		19	10	48		11		26	8	33		30		17	4	54		--------
16°		09		08		04	11	58	11	49	11	37	11	22		03	10	40		11	9	36	8	54		04		04	5	56		--------		--------
15°	11	24	11	23	11	19		14		05	10	54	10	40	10	22	10	00	9	33	9	00		21	7	34	6	38		34		--------		--------
14°	10	39	10	37	10	34	10	29	10	21		11	9	58	9	41	9	21	8	55	8	25	7	48		04		12		12		--------		--------
13°	9	53	9	52	9	49	9	44	9	37	9	28		16	9	00	8	41		18	7	49		15	6	34	5	46	4	50		--------		--------
12°		08		07		04	9	00	8	53	8	44	8	33	8	19		01	7	40		13	6	42		04		20		28		--------		--------
11°	8	23	8	22	8	19	8	15		09		01	7	51	7	38	7	21		02	6	38		09	5	34	4	54		06		--------		--------
10°	7	37	7	36	7	34	7	30	7	25	7	17		08	6	56	6	42	6	24		02	5	35		04		27	3	44		--------		--------
9°	6	52	6	51	6	49	6	45	6	41	6	34	6	26		15		02	5	45	5	26		02	4	34	4	00		22		--------		--------
8°		06		05		04		01	5	56	5	50	5	43	5	33	5	22		07	4	50	4	29		04	3	34	2	59		--------		--------
7°	5	20	5	20	5	18	5	16		12		07	5	00	4	52	4	41	4	29		14	3	55	3	33		07		37		--------		--------
6°	4	35	4	34	4	33	4	31	4	27	4	23	4	17		10		01	3	51	3	37		22		03	2	41		15		--------		--------
5°	3	49	3	49	3	47	3	46	3	43	3	39	3	34	3	29	3	21		12		01	2	48	2	33		14	1	52		--------		--------
4°		03		03		02		01	2	58	2	55	2	52	2	47	2	41	2	34	2	25		15		02	1	47		30		--------		--------
3°	2	17	2	17	2	16	2	15		14		12		09		05		01	1	55	1	49	1	41	1	32		20		07		--------		--------
2°	1	32	1	31	1	31	1	30	1	29	1	28	1	26	1	23	1	21		17		12		07		01	0	54	0	45		--------		--------
1°	0	46	0	46	0	45	0	45	0	45	0	44	0	43	0	42	0	40	0	38	0	36	0	33	0	31	0	27	0	22		--------		--------

ATMOSPHERIC WAVES ON ISENTROPIC SURFACES AS EVIDENCED BY INTERFRONTAL CEILING OSCILLATIONS

By Woodrow C. Jacobs

[Scripps Institution of Oceanography, La Jolla, Calif., and U. S. Weather Bureau Airport Station, San Diego, Calif., April 1936]

One cannot long be a student of dynamic oceanography without coming to realize the importance of wave motion in any fluid body. A natural tendency for a meteorologist who had undertaken such a study would be to attempt an application of the principles of wave motion to that greatest of all terrestrial fluid bodies, the atmosphere. The formation, characteristics, and effects of ocean waves are apparent to all who have viewed the sea, hence it is only natural that they should have received the attention of oceanographers at an early date. Atmospheric waves, on the other hand, are not nearly so apparent; and while they may be far greater in magnitude than those in even the wildest sea, they are noted by comparatively few casual observers, and probably for this reason, among others, they have not been given proportionate attention by meteorologists. However, the formation of smoke waves and the high altitude billow cloud has been attributed to their effects; and their existence, as evidenced by pressure, temperature, wind and precipitation fluctuations, has been studied and described by various investigators.

Von Helmholtz (1), writing during the latter part of the nineteenth century, showed that whenever two fluids of different densities flow one over the other with unequal velocities, wave motion is induced at the surface of juxtaposition of the two fluids. It seems logical to assume that any wave, propagated on the surface of discontinuity between two air masses with different entropies, would be evidenced by a corresponding wave effect in any cloud stratum which might form at such a surface through either adiabatic or radiative processes of cooling.

CEILING OSCILLATIONS OBSERVED AT SAN DIEGO

This reasoning appears to be validated by two interesting cases of interfrontal ceiling oscillation, showing this wave effect, which were recently observed by the writer at the Weather Bureau Airport Station, San Diego, Calif., and which occurred at times when careful measurement of the period and amplitude of fluctuation was possible. Ceilings in the San Diego area normally remain fairly constant, any change being a slow lowering or a more rapid raising coincident with frontal movements, diurnal fluctuations, or occasionally, especially with very low ceilings, a rapid variation of cloud height with sudden changes in wind direction or velocity.

Shortly after sundown on January 15, 1936, however, it was noted that the cloud height appeared to be fluctuating a great deal; this fact was a matter for some concern, because ceilings were originally very low, and it was a question of how long flying conditions would remain hazardous at Lindbergh Field. Accordingly, at 7:05 p. m., observations of ceiling height were begun, and measurements taken at intervals of 5 minutes until 8:05 p. m. From that time, since it was apparent that the frequent oscillatory motion was slowing down, the measurements were made at 10-minute intervals until 11:05 p. m. The 5 p. m. synoptic chart showed the presence of a weak cold front a short distance to the northwest of San Diego; while at 11 p. m., airway weather reports indicated that the front had passed all stations on the coast, and was advancing rapidly eastward, a fresh NPP (transitional polar Pacific) air mass then occupying the entire region. Previous to 7 p. m. the ceiling had been lowering slowly, but no oscillatory motion was noted until shortly before the comparative observations were initiated. The rapid rise in ceiling which took place at 8:45 p. m. (fig. 1) was concomitant with the passage of the cold front, and marked the cessation of the oscillations. The cloud type at this time changed from the characteristic prefrontal stratus to stratocumulus which, at 11 p. m., began to break somewhat, necessitating the termination of the interesting series of observations.

An examination of figure 1 reveals that the fluctuations before 9 p. m. (previous to the passage of the cold front) tend to occur at more or less regular intervals. Whatever irregularity may be in evidence can be accounted for, in part, by the method of observation; a continuous record of the ceiling oscillation was not possible. In each case it may be observed that the lag or advancement of the wave crest is a whole number of the observational intervals. Between 7:10 p. m. and 8:45 p. m. there were six complete oscillations, giving an average period of 15.8 minutes. The amplitudes of the waves, on this occasion, were somewhat variable, which would be expected under the influence of such rapidly changing physical conditions; the average was 22.8 meters with an extreme amplitude of 53 meters. The average height of the ceiling during the period of oscillation was 185 meters, which for the purpose of this study is taken to be the altitude of the discontinuity surface, the assumption being that the stratus clouds formed directly above this surface.

On February 22, 1936, a similar situation presented itself and observations of ceiling height were made at approximately 10-minute intervals from 6:15 p. m. until 11:55 p. m. On this occasion the oscillatory movement was even more pronounced than in the preceding case, the wave effect being unmistakably present; and a longer series of observations was possible, as no front passed the station during the period. The cloud layer remained uniform and unbroken throughout the entire 6 hours. It appears that in this case the discontinuity surface existed between a shallow wedge of NPP (transitional polar Pacific) air at the surface and a slowly overrunning mass of TP (tropical Pacific) air above. The cold front, followed by PP (polar Pacific) air, did not pass the station until shortly after 5 a. m. the next morning, 5 hours after this series of observations had been terminated.

An inspection of the data plotted in figure 1 reveals that the fluctuations were definitely isochronal. Between 6:15 p. m. and 9:15 p. m. the period between successive crests was exactly 40 minutes; this interval shortened somewhat during the next hour and one-half, which a later mathematical consideration will show would be expected of waves formed on a steadily lowering discontinuity surface. Between 6:35 p. m. and 10:55 p. m. there were seven complete oscillations giving an average period of 37.1 minutes. The average amplitude was 34.6 meters with an extreme of 70 meters. The average height of the ceiling from 6:15 p. m. until 10:55 p. m. was 158 meters which, again, is assumed to be the altitude of the discontinuity surface.

In both of these cases the characteristic weather phenomena were those which would be expected to precede rather than follow the passage of the warm front; such a

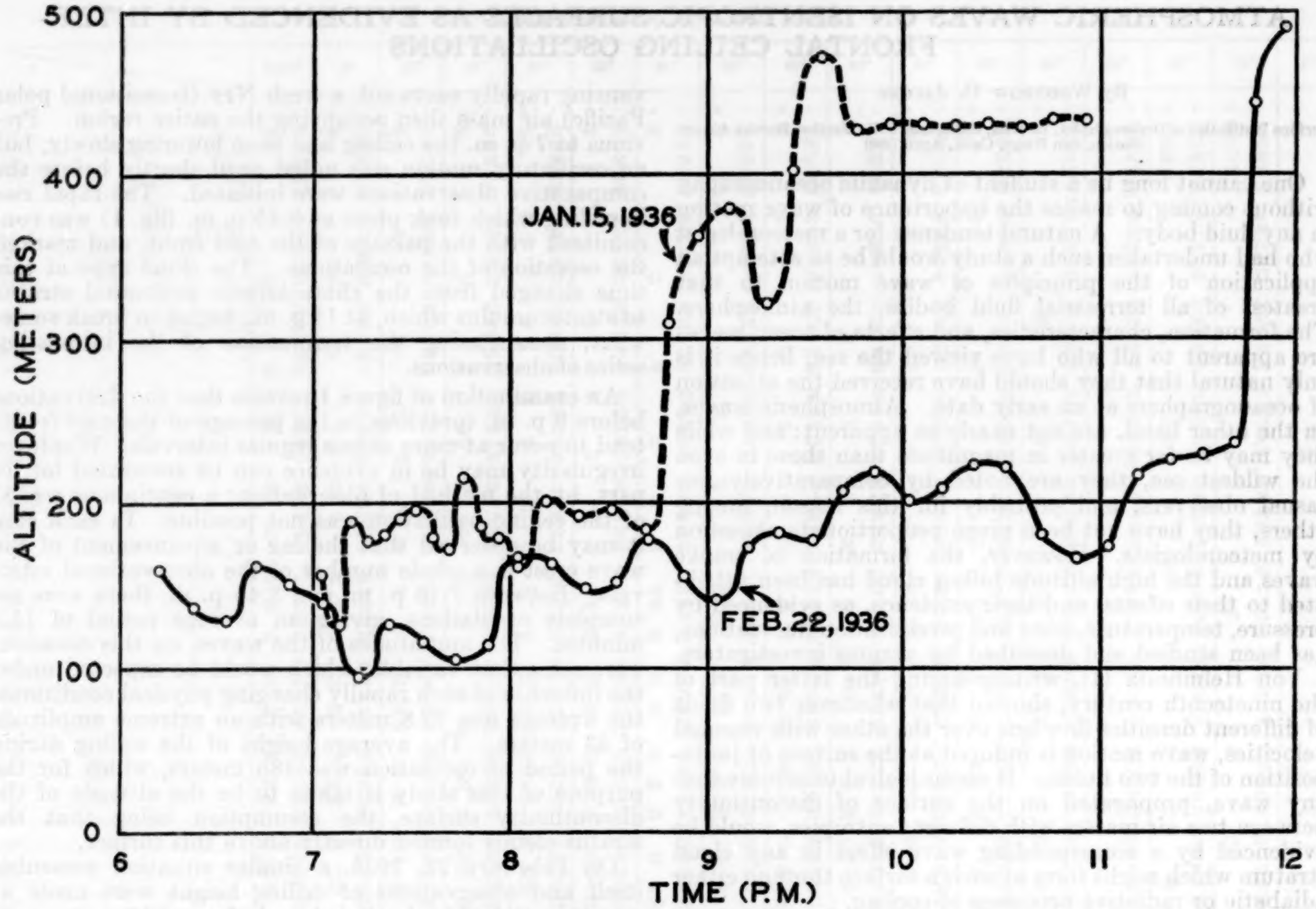

FIGURE 1.—Ceiling oscillation at San Diego, Calif.

condition, however, is not unusual in the warm sector of the cyclone in this region, since orographic influences are of prime importance. There is little doubt that these oscillations were Helmholtz waves induced along the surface of discontinuity between two masses of air of different entropy; such a surface might be formed between a shallow wedge of colder maritime air entrapped at the surface against the low hills or mountain ranges which parallel the coast in this region, and an overrunning layer of warmer maritime air above—the whole process probably an entirely local phenomenon.[1]

METHOD OF DETERMINING CEILING HEIGHTS

The ceiling heights were determined by the use of the ceiling-light projector and Marvin clinometer; and care was exercised to be certain that each observation was representative and included several distinct measurements each time. It is realized that this method of cloud height determination is subject to some error, especially with the higher ceilings over 600 meters, but it is felt that any error of observation would be a negligible part of the fluctuations actually observed and should tend to be constant, either slightly too high or too low.

[1] According to Byers a similar discontinuity surface might be produced in a tropical maritime air mass which has been cooled in the lower levels because of its long trajectory over colder waters, and has been rendered extremely stable by the time it has reached San Diego. Inasmuch as the amplitude of such waves decreases rapidly with increasing distance from the surface of origin, it is doubtful that the wave effect could be evidenced by ceiling oscillations in a cloud stratum formed beneath such a surface unless the cloud layer were thin or the amplitude of the waves great.

TABLE 1.—*Amplitudes of half-waves*

Wave no. X2	Amplitude of ½ wave[1]	
	Jan. 15, 1936	Feb. 22, 1936
	Meters	*Meters*
1	53	32
2	13	70
3	17	31
4	24	23
5	43	61
6	36	21
7	2	28
8	19	38
9	39	38
10	10	4
11	3	39
12	15	18
13		21
14		60
Average	22.8	34.6

[1] The difference in height between 1 crest and the following trough, etc.

It is true that a similar appearance of ceiling oscillation might be produced by a series of measurements of the heights of the base of a cloud stratum which was irregular or partially broken in some sequential manner. On January 15, however, the clouds presented the uniform appearance characteristic of the stratiform type until after the passage of the cold front; on February 22 the clouds remained uniform throughout the entire 6-hour period covered by the observations. In both cases surface winds were light and constant in direction, and no scud or breaks in the overcast were observed.

BAROMETRIC OSCILLATIONS IN CONJUNCTION WITH THE WAVES

An examination of the barogram for January 15 revealed a slight wavy appearance of the trace from 6 p. m. until 9 p. m. in what was otherwise the record of a slowly rising barometer. A pressure oscillation was hardly noticeable on February 22. In both cases the fluctuation was less than 0.3 mb. Unfortunately the record of a microbarograph for these periods was not available; and a more thorough examination of the pressure fluctuations on the ordinary barogram obviously was impossible.

Fluctuations of other meteorological elements, such as are commonly regarded as indicators of atmospheric waves, were absent. Since no rain fell during either of the two periods under consideration, it was impossible to determine whether waves of these amplitudes would produce corresponding fluctuations in precipitation. Simple computations show, however, that any adiabatic cooling or heating due to the waves would be very slight and, therefore, any variation in precipitation from these causes would, of necessity, be exceedingly small. No periodic fluctuations in wind or temperature were observed, but such effects would not be expected unless the point of observation were in such a position relative to the discontinuity that the wave surface would be first above and then below this point.

MATHEMATICAL ANALYSIS OF DATA FOR FEBRUARY 22

A theoretical discussion of the wave lengths and velocities requires a knowledge of upper air conditions. Unfortunately on January 15 the Naval Air Station at North Island (2½ miles southwest of Lindbergh Field) did not make a morning aerographic airplane flight, nor did the Weather Bureau undertake the usual afternoon pilot balloon sounding. On February 22, however, both these observations were made; and although they preceded the time of ceiling measurements by a considerable period they may be utilized to give a fairly representative picture of the general conditions which prevailed aloft at the time. The aerographic sounding made at 6 a. m. on this date showed a temperature of 14° C. at the surface, and 17° C. at an elevation of 590 meters, a temperature inversion of 3° C. This inversion level is, of course, considerably above the height assumed 12 hours later, but it would be expected that some lowering of the discontinuity surface would have occurred during the intervening period. The pilot balloon flight made at 1:46 p. m. showed a marked wind discontinuity at 500 meters; but the practice of observing the balloon position at 180 meter intervals and computing by 2-minute periods tends to smooth out any sudden wind discontinuity, and the actual level may have been as much as 360 meters below that indicated. The upper air winds below 1,000 meters at the time were as follows:

	Meters per second
Surface, west	1.8
250 meters, northwest	3.8
500 meters, northwest	2.0
750 meters, south-southwest	0.8
1,000 meters, southwest	3.2

Above this level the wind continued from the wouthwest and increased rapidly in velocity with elevation; it was southwest, 23.6 miles per second, at 5,300 meters, the maximum altitude reached.

The wave length (λ) of any simple transverse wave may be expressed as

$$\lambda=\frac{U}{\mu}\equiv U\tau \tag{1}$$

where U is commonly assumed, as a first approximation, to be one-half the difference in speed between the two layers, μ is the frequency of oscillation, and τ the period. Taking on the basis of the above data the arbitrary but reasonable value $2U=4.0$ meters per second, the wave length is found to be 4,452 meters. A similar value of U for January 15 gives a wave length of 1,896 meters on that date. Both these values compare favorably with those derived by Haurwitz (2) for pressure oscillations produced under similar conditions at Blue Hill Observatory in December 1933.

The wave length may also be expressed in terms of temperature and difference in velocity (2):

$$\lambda=\frac{\left(\frac{2\pi}{g}\right)U^2T_2}{T_1\left(1-\frac{U^2}{gh}\right)-T_2} \tag{2}$$

where g is gravity acceleration, T_1 the temperature in the upper layer, T_2 the temperature in the lower, and h the thickness of the lower layer or the height of the discontinuity surface. Inasmuch as there is a direct linear relation between temperature and density, T in these equations may be replaced by ρ without appreciable error. This formula should be applied when $\lambda/20>h$ which, from (1), is found to be true for February 22. The upper air data for 6:00 a. m. of that date give $U=2.0$ meters per second, $T_1=290°$ A, $T_2=287°$ A, and $h=158$ m, but the inadmissible figure of 241 m is then found for λ. Examination of (2) shows that λ increases with either increasing U or decreasing ΔT.[2] Evidently then, either $2U>4.0$ meters per second or $T_1-T_2<3°$. The value for U seems reasonable under the conditions observed, but a smaller value for ΔT appears proabable. Now, equation (2) can readily be transformed into the following (2):

$$T_1-T_2=\frac{U^2}{g}\left(\frac{T_1}{h}+\frac{2\pi T_2}{\lambda}\right) \tag{3}$$

Substituting the same value for U, taking the values for T_1 and T_2 on the right as equal to 287° (the observed surface temperature throughout the 6-hour period), and the value of λ derived from (1), T_1-T_2 is found to be 0.9°, which is an entirely reasonable figure.[3] On the other hand, from (2) or (3),

$$U=\left[\frac{g\Delta T}{\frac{T_1}{h}+2\pi\frac{T_2}{\lambda}}\right]^{1/2} \tag{4}$$

and substituting in this equation the values for h, T_1 and T_2 which were observed, namely, 158 m, 290° and 287° respectively, 2U is found to be 7.4 meters per second which is, however, too large a value under the observed conditions.

[2] Decreasing Δ T to a certain limiting value would give negative figures in the denominator of equation (2), rendering values for λ meaningless. Decreasing it still farther would bring $T_2>T_1$ in which case there would no longer be an inversion but a condition approaching instability, where the formulae obviously could not apply.

[3] Actually the temperature difference would be slightly smaller, because the effect of compressibility has been disregarded, and the oscillations assumed to be simple transverse waves.

The velocity of propagation of surface waves, such as those between air and water, is given by

$$V=\sqrt{gh} \tag{5}$$

when the depth h is small compared to the wave length; here, however, $\Delta\rho/\rho_1$ is taken as unity; in a consideration of internal waves formed between two similar fluid bodies, a correction for small differences in density must be applied, and according to Ekman (**3**), equation (5) becomes

$$V=\sqrt{\frac{gh\Delta\rho}{\rho_1}}\cong\sqrt{\frac{gh\Delta T}{T_1}}, \tag{6}$$

in which ρ_1 is the density of the upper layer. Assuming ΔT to be 3° and T_1 to be 287°, a velocity of propagation of 4.0 meters per second is found. By taking ΔT as 0.9° and T_1 as 287.9° a velocity of propagation of 2.1 meters per second is found, which checks with the computed velocity of 2.0 meters per second for the wave length of 4,452 meters and period of 37.1 minutes.

WAVES ON AIR AND WATER SURFACES COMPARED

Waves in the atmosphere and in the sea have previously been compared, in a general way, as to magnitude; a similar comparison of the energy of wave forms in the two media is also possible. In any wave, two forms of energy occur; namely, the potential energy of the deformation and the kinetic energy of the motion. If, then, the energies of the waves in the two media are to be compared, a comparison of the densities of the two fluids is all that is necessary, assuming that the velocities are equal, and neglecting, for the time being, the effect of the different compressibilities of air and water. If the surface of the sea be at 14° C. (salinity 35.00) and the atmosphere (dry air) at 14.9° C. (pressure 1,013.3 mb), the ratio of densities is 1:0.001. It follows that waves formed on a level sea surface, corresponding to the atmospheric waves observed on January 15 and February 22, would be insignificant ripples of amplitudes 22.8 millimeters and 34.6 millimeters, respectively.

Helmholtz (**1**) concludes from the principle of mechanical similarity that if waves between two air masses (with a temperature discontinuity of 10° C.) and between air and water (both at 0° C.) are to be similar, the quantities

$\frac{\sigma}{1-\sigma}\cdot\frac{b_1^2}{n}$ and $\frac{1}{1-\sigma}\cdot\frac{b_2^2}{n}$ must remain unchanged, where σ denotes the ratio of densities on either side of the discontinuity, b_1 and b_2 the velocities parallel to the surface of discontinuity, and n the linear dimension.

He finds that for the waves formed on these two surfaces, with the same wind velocity, to be geometrically similar, the wave length of the air wave must be increased in the ratio of 1 to 2630.3. With the same ratios, sea waves corresponding to the atmospheric waves on January 15 and February 22 would have wave lengths of 0.7 m and 1.7 m, respectively.[4]

Helmholtz' comparison of the internal waves fo the atmosphere with surface waves of the sea is, however, misleading inasmuch as two entirely different wave forms are being considered. According to McEwen and Chambers, of the Scripps Institution, if internal waves in the sea, such as boundary waves, be considered instead of surface forms, the wave lengths and the amplitudes would be more nearly comparable to those of atmospheric waves.

CONCLUSION

Whether manifested by ceiling oscillations or by turbulent conditions aloft, the existence of atmospheric waves is of importance to the aerographer, the airplane pilot, and the airway weather forecaster. The study of atmospheric waves under different meteorological conditions and as influenced by various topographical features, with the end in view of forecasting their occurrence and effects, should prove to be of vital importance to these groups, and of interest to the meteorologist. Additional studies of ceiling oscillations, similar to the pressure oscillation studies by Haurwitz, Stone, and Brooks (**2**), Clayton (**4**), Lamb (**5**), Namekawa (**6**), and Murase (**7**), might reveal interesting facts regarding the formation and effects of atmospheric waves on isentropic surfaces.

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[4] The "breaking" effect commonly observed in water waves at shallow depths was not evident. It appears that the slopes of the curves in figs. 1 and 2 are as often steeper in the posterior portions as otherwise.

WEATHER OF 1936 IN THE UNITED STATES

By J. P. KOHLER

[Weather Bureau, Washington, D. C., February 1937]

The weather during the year 1936 was characterized by marked extremes in temperature and precipitation. Unparalleled prolonged periods of subzero temperatures obtained in many Western States in the early months of the year followed by unprecedented drought conditions during the summer months.

January and February 1936 brought the most severe weather ever experienced to several States in the north and middle sections of the Mississippi and Missouri Valleys; also locally in parts of the Ohio Valley. In the month of January only six States, namely, California, Colorado, Nevada, Oregon, Utah, and Washington had average temperatures above normal. The greatest negative departures were centered in the northern portions of the Missouri and Mississippi valleys. The mean temperature for North Dakota was −5.8°, or 12.1° below normal; likewise in Minnesota the departure from normal was −10.8°; South Dakota, −10.2°; Iowa, −9.0°; and

Annual Temperature Departures (°F) in the United States, 1936

(Plotted by J. P. Kohler)

Annual Precipitation Departures (inches) in the United States, 1936

(Plotted by J. P. Kohler)

Wisconsin, −6.0°. The lowest for the month was −55° at Warroad, Minn., on the 23d. In Kentucky a new monthly minimum was established with a temperature of −25°.

The winter reached its most severe stage in February. Only two States, Nevada, and Utah reported an average temperature above normal. The maximum negative departures, as in January, were centered in the northern portions of the Great Plains, the Mississippi and Missouri Valleys. New low mean temperature records were established in eight States, namely, Iowa, 6.0°, departure from normal, −16.3°; Missouri, −5.5°, departure, −17.8°; Montana, −0.1°, departure −22.3°; Nebraska, 8.9°, departure −17.3; North Dakota, −12.9°, departure −22.6°; South Dakota, −3.8°, departure −22.3°; Wisconsin, 2.8° departure −19.6°; and on the Pacific coast the State of Washington experienced an unusually severe month, the mean temperature being 22.5°, or 12.7° below normal, establishing a new low mean temperature for the State. The lowest minimum of the month and also a new record for the State of North Dakota was 60° below zero which occurred at Parshall on the 15th; the latter is within 6° of the lowest temperature ever reported in this country—66° below zero at Riverside Ranger station, Yellowstone Park, Wyo., in February 1933. Two other States in this area, namely, South Dakota and Wisconsin with minima of −58° and −52° established new minimum records. The highest minimum for the month was 18° which occurred at Quincy, Fla.

There was a sudden reversal toward warmer weather during the month of March, and only three stations reported mean temperatures below the average. Areas which in the preceding 2 months were from 10° to 20° below normal reported positive departures of as much as 5°.

The month of April 1936, was cool for the season over nearly all sections east of the Rocky Mountains and warmer than normal quite generally west of the Rockies. The monthly departures from normal temperature over the eastern two-thirds of the country ranged generally from deficiencies of 1° or 2° in the more southern sections to 4° or more in the area from the Lake region westward to the northern Great Plains. Along the Atlantic coast the month had about normal warmth. West of the Rocky Mountains plus departures from normal temperatures ranged generally from 3° to 6°. Notwithstanding the fact that average temperature departures were not excessive, several States reported the lowest monthly minimum of record; Arkansas with 17°, Idaho −21°, Nebraska −15°, Oklahoma 6°, Oregon −23°, and Washington −7°. Precipitation was much above normal over the States bordering the Atlantic coast, and quite generally along the Pacific coast, and over the north and central portions of the Rocky Mountain States. The greater portion of the country between the Rocky Mountains and the Appalachians had below normal rainfall. The area of maximum deficiencies centered over Oklahoma, Kansas, Arkansas, and Missouri.

In parts of the United States the next 5 months, May, June, July, August, and September, were almost constantly above normal temperatures. Scanty rainfall together with excessive heat during this period produced the most severe drought in the history of agriculture in the United States. In May every section and State reported their mean temperature above normal. Only three States, California, Michigan, and Minnesota, had temperatures below normal in June. The New England district was the only section below normal in July. Two States, Idaho and Kentucky, averaged slightly below normal in September, and in August every State and section, with the exception of the northern part of the New England district, reported mean temperatures above normal.

At the close of June high temperatures and the monthly accumulated deficiencies of rainfall began to materially affect crop conditions in the midwestern States. New maximum monthly temperatures were established in the following eight States: Arkansas, 113°; Indiana, 111°; Kentucky, 110°; Louisiana, 110°; Mississippi, 111°; Montana, 111°; Nebraska, 114°, and Tennessee, 110°. Previous high records were equalled in the following States: Colorado, Missouri, and Nevada.

During August a new record maximum was established in the following 15 States: Illinois, 115°; Indiana, 116°; Kansas, 121°; Michigan, 112°; Missouri, 118°; Montana, 113°; Nebraska, 118°; New Jersey, 110°; North Dakota, 121°; Oklahoma, 120°; Pennsylvania, 109°; West Virginia, 112°, and Wisconsin, 114°. The average departures from normal were exceptionally large in most States in the Mississippi and Missouri Valleys. In the Dakotas the excess exceeded 11°.

In August the heat wave over the midwestern and interior valley States continued unabated. Nine States established new maximum records: Arizona with 120°; Indiana, 111°; Kansas, 119°; Louisiana, 114°; Missouri, 116°; Nebraska, 117°; Oklahoma, 120°; South Dakota, 116°; and Texas, 120°. Several States in the Corn and Wheat Belts had average temperatures considerably in excess of any previous record; but, in general, positive departures averaged less than in the preceding month.

Tables 1 and 2 show the average temperature and precipitation conditions existing in the States most affected by the 1936 drought. Less than 70 percent of the normal rainfall for the crop-growing season occurred in Montana, the Dakotas, Nebraska, Kansas, Minnesota, Missouri, and Arkansas.

The persistent and universal prevalence of high temperatures in the agricultural States of the midwest is best shown by table 3. For example, in Oklahoma from July 14 to almost the close of the month practically all stations reported a maximum of 100° or above. In the period from August 2 to 28, similar conditions prevailed.

Tables 4 and 5 are included according to the custom of previous years.

The accompanying charts 1 and 2 are based on reports from some 180 stations showing temperature and precipitation departures in the United States for the year based on data obtained at regular Weather Bureau stations.

TABLE 1.—*Mean temperatures and departures from normal for States in and bordering the drought area during 1936*

State	March		April		May		June		July		August		September	
	Average temperature	Departure from normal	Average temperature	Departure from normal	Average temperature	Departure from normal	Average temperature	Departure from normal	Average temperature	Departure from normal	Average temperature	Departure from normal	Average temperature	Departure from normal
Montana	30.8	+0.1	41.8	−1.1	59.0	+7.2	63.9	+4.1	74.3	+7.4	67.4	+2.6	56.6	+1.9
Wyoming	29.3	−.5	39.9	−.2	55.4	+6.0	63.0	+4.3	71.0	+5.4	66.1	+2.3	54.5	+.3
Colorado	36.9	+2.4	45.5	+1.9	56.5	+4.3	66.1	+4.5	70.8	+3.7	68.0	+2.6	58.5	+.6
New Mexico	44.8	+1.0	52.0	+.4	61.1	+1.5	70.7	+1.8	72.5	+.2	71.7	+1.1	62.9	−1.5
North Dakota	25.5	+1.2	35.6	−6.0	61.0	+8.2	66.4	+3.9	79.9	+11.8	69.8	+3.6	60.3	+4.0
South Dakota	33.7	+2.8	41.6	−4.3	63.3	+6.8	71.4	+4.8	84.2	+11.2	76.3	+5.7	65.4	+3.9
Nebraska	40.5	+4.2	47.1	−2.1	64.2	+5.2	72.7	+3.6	83.6	+8.3	79.4	+6.4	67.4	+3.3
Kansas	48.5	+5.2	54.5	−.2	67.7	+3.9	77.3	+3.5	85.7	+6.7	85.3	+7.7	72.5	+2.9
Oklahoma	56.3	+5.6	61.0	+.7	71.2	+3.0	80.8	+3.6	86.5	+4.8	88.0	+6.6	76.6	+2.4
Texas	62.0	+3.5	65.0	−1.1	73.5	+.5	82.1	+1.9	82.5	−.5	84.4	+1.6	77.9	+.6
Minnesota	26.4	+.1	36.4	−6.6	60.5	+5.4	63.9	−1.0	77.1	+7.1	70.7	+3.4	62.0	+3.0
Iowa	39.2	+4.7	45.9	−2.8	66.2	+6.2	70.1	+.5	83.4	+8.8	79.2	+7.2	68.0	+4.3
Missouri	49.4	+5.6	53.0	−2.2	68.8	+4.4	76.5	+2.9	85.3	+7.3	84.6	+8.2	73.6	+4.4
Arkansas	57.1	+4.5	59.7	−1.8	70.9	+1.8	80.0	+2.9	83.3	+2.8	85.0	+5.0	78.9	+4.5
Louisiana	63.3	+2.7	65.2	−1.9	74.0	+.3	81.9	+1.8	82.1	+.3	83.1	+1.3	80.9	+2.9
Tennessee	53.2	+3.9	56.1	−2.6	69.9	+3.1	78.2	+3.5	80.3	+2.6	80.6	+4.0	75.4	+3.9
Kentucky	50.7	+4.4	53.1	−3.0	68.3	+2.9	76.1	+2.2	81.4	+4.2	81.1	+5.3	74.4	+3.8
Illinois	44.8	+4.7	49.0	−3.1	67.4	+4.9	72.8	+1.2	83.5	+7.1	81.0	+6.9	71.2	+4.2
Indiana	44.6	+4.0	47.8	−4.0	65.8	+3.6	71.8	+.3	81.4	+5.7	79.4	+5.9	70.7	+3.5
Ohio	43.0	+4.2	46.2	−3.5	64.1	+3.6	70.3	+.8	77.0	+3.3	76.1	+4.5	69.3	+3.6
Michigan	32.7	+2.9	38.3	−4.4	58.5	+4.5	62.3	−1.7	71.9	+2.8	69.0	+2.2	62.2	+1.8
Wisconsin	30.8	+1.5	38.1	−5.5	60.4	+5.2	62.8	−2.3	75.2	+5.1	70.7	+3.3	62.9	+2.6

TABLE 2.—*Average amounts of rainfall and departures from normal for States in and bordering the drought area during 1936*

State	March		April		May		June		July		August		September		Total March–September	Percent of normal
	Total rainfall	Departure from normal	Total rainfall	Departure from normal	Total rainfall	Departure from normal	Total rainfall	Departure from normal	Total rainfall	Departure from normal	Total rainfall	Departure from normal	Total rainfall	Departure from normal		
Montana	0.72	−0.24	0.82	−0.33	1.07	−1.13	1.78	−0.72	0.73	−0.75	1.02	−0.12	0.95	−0.41	7.09	66
Wyoming	1.17	.00	1.13	−.46	.52	−1.60	1.82	+.22	1.55	+.25	1.26	+.16	.70	−.44	8.15	81
Colorado	.99	−.31	.80	−.99	1.73	−.18	1.41	+.01	2.15	−.07	2.68	+.72	1.63	+.31	11.39	96
New Mexico	.32	−.43	.31	−.58	1.78	+.63	.94	−.30	2.07	−.49	1.98	−.51	2.78	+1.17	10.18	95
North Dakota	.81	+.05	.39	−1.07	.80	−1.54	1.34	−2.09	.70	−1.82	1.36	−.71	1.15	−.43	6.55	46
South Dakota	.78	−.34	1.28	−.88	1.67	−1.31	1.32	−2.21	.62	−1.98	1.58	−.71	.74	−.93	7.99	49
Nebraska	.57	−.53	1.59	−.86	3.20	−.33	2.01	−1.75	.57	−2.77	1.60	−1.22	1.78	−.36	11.32	59
Kansas	.14	−1.30	1.17	−1.42	4.88	+1.11	1.26	−2.74	.86	−2.38	1.06	−2.11	4.84	+2.03	14.21	68
Oklahoma	.51	−1.69	.99	−2.41	4.49	−.25	1.97	−1.87	.71	−2.28	.22	−2.78	7.85	+4.78	16.74	72
Texas	1.02	−1.08	1.69	−1.39	6.52	+2.52	1.59	−1.52	4.15	+1.53	1.52	−.90	7.04	+4.11	23.53	116
Minnesota	1.50	+.31	1.30	−.76	2.52	−.65	1.87	−2.19	.73	−2.63	2.90	−.28	2.07	−.81	12.89	67
Iowa	1.02	−.71	1.10	−1.63	2.91	−1.18	2.85	−1.80	.51	−3.22	3.48	−.06	7.22	+3.41	19.09	79
Missouri	1.27	−1.91	2.45	−1.42	2.52	−2.29	1.42	−3.42	1.52	−2.25	.84	−3.07	8.62	+4.49	18.64	65
Arkansas	2.19	−2.60	2.64	−2.25	2.50	−2.57	1.26	−2.83	4.90	+1.12	.40	−3.25	4.75	+1.38	18.64	63
Louisiana	2.07	−2.72	4.32	−.33	5.13	+.52	.53	−4.12	6.42	+.26	4.48	−.58	2.73	−1.18	25.68	76
Tennessee	6.77	+1.36	4.32	−.11	1.31	−2.84	1.04	−3.21	6.75	+2.34	2.18	−1.85	3.10	+.03	25.47	86
Kentucky	4.85	+.14	4.79	+.83	1.50	−2.54	.81	−3.38	3.78	−.36	2.22	−1.51	3.57	+.61	21.52	78
Illinois	1.70	−1.37	2.44	−.95	2.07	−2.09	1.66	−2.43	1.22	−2.07	2.66	−.69	6.77	+3.14	18.52	74
Indiana	2.74	−1.02	3.17	−.32	2.02	−2.04	1.37	−2.26	1.59	−1.76	3.08	−.30	4.84	+1.44	18.81	75
Ohio	3.64	+.27	2.92	−.20	1.78	−1.91	1.74	−2.04	3.06	−.74	3.54	+.16	3.18	+.19	19.86	82
Michigan	1.09	−1.08	2.04	−.53	2.11	−1.09	2.00	−1.12	1.10	−1.75	3.46	+.81	5.01	+1.78	16.81	85
Wisconsin	1.58	−.19	1.28	−1.26	2.70	−.90	2.29	−1.76	1.01	−2.59	5.20	+2.01	3.48	−.18	17.54	78

TABLE 3.—*Summary of selected stations with daily maxima of 100° or above*

State and month	Number of station records examined	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
North Dakota:																																	
May	51	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
June	51	----	----	----	----	----	----	----	----	----	----	----	2	1	----	----	----	----	3	----	----	----	----	----	44	24	3	14	8	----	----	----	8
July	50	----	4	2	9	38	50	40	37	30	47	49	37	30	10	40	46	45	40	8	----	16	2	13	9	26	5	----	----	----	11	28	26
August	51	16	3	----	----	----	2	13	12	1	23	4	----	----	7	3	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	11
September	50	----	----	1	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10	----	----	----	----	----	----	----	----	----	3
South Dakota:																																	
June	41	----	----	----	----	----	----	----	----	----	----	----	----	12	----	23	13	----	12	1	----	----	----	----	27	38	16	30	27	9	1	----	12
July	41	1	22	21	37	36	41	38	35	40	39	38	31	25	16	40	40	38	39	36	4	15	35	27	33	32	24	4	1	----	----	13	29
August	41	30	14	1	----	1	3	11	35	17	18	25	3	3	14	32	4	11	10	2	----	----	1	25	14	3	----	----	----	----	----	7	23
September	51	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	20	1	----	----	----	----	----	----	----	----	3
Nebraska:																																	
June	45	----	----	----	----	----	----	----	----	----	----	----	----	1	5	20	3	1	11	7	6	9	3	----	3	37	31	28	42	15	1	----	17
July	46	----	12	45	46	46	20	9	16	43	43	28	20	29	28	44	45	45	43	45	2	1	43	41	44	46	40	18	6	1	----	1	29
August	46	11	26	2	----	----	----	----	21	37	32	34	34	28	28	37	34	41	32	9	10	4	1	29	44	18	15	26	1	----	----	1	25
September	61	4	----	----	----	2	12	----	----	1	17	2	----	----	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	7
Kansas:																																	
June	75	----	----	----	----	----	----	----	5	----	----	----	----	1	17	23	12	42	62	74	64	62	22	----	1	43	73	68	74	62	9	----	18
July	75	1	16	62	65	50	11	7	15	41	55	46	40	58	74	75	74	75	75	75	62	11	67	75	75	75	74	72	27	7	----	----	29
August	74	3	43	33	32	----	2	15	40	71	72	70	74	74	74	74	74	74	74	67	59	51	39	69	72	74	56	4	----	----	----	21	27
September	73	35	12	1	2	34	41	15	19	3	47	33	3	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	13
Oklahoma:																																	
April	50	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	2
May	50	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
June	49	----	----	----	----	----	1	----	6	8	2	----	----	----	2	17	24	24	47	35	46	48	44	6	----	4	32	45	38	21	7	----	20
July	48	2	1	22	27	6	2	4	4	13	25	17	24	43	47	46	39	47	48	48	48	27	36	42	41	34	43	48	46	42	14	1	31
August	48	1	36	38	45	38	33	45	47	48	48	48	48	48	48	48	48	47	47	47	46	45	43	45	47	43	44	37	22	1	1	9	31
September	49	25	37	6	8	31	40	40	24	30	38	19	11	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	13

TABLE 3.—*Summary of selected stations with daily maxima of 100° or above*—Continued

State and month	Number of station records examined	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Texas:																																	
April	60					4																							1	3	1		4
May	60	1			1				1									2			1												5
June	54		2	1		4	4	7	12	13	8	5	4	3	1	13	13	15	11	6	14	37	29	13	5	5	9	15	7	3	6		28
July	55	5		2	3		1			1	2	4	5	7	5	13	2	10	20	29	24	14	8	9	5	5	8	13	14	18	11		26
August	56	1	6	6	11	13	17	19	29	39	44	45	34	31	30	22	18	18	20	14	15	17	17	29	27	22	13	4	5	2	2	1	31
September	56	4	11	3	7	13	11	5	6	11	11	9	5	3	1	1			1	1	1	1	1										20
Minnesota:																																	
June	45																								1	5		2					3
July	45				3	2	36	33	25	16	37	43	44	44	29	22	35	16	11	2			5	1									18
August	46		1						4	1		2				23								1	7								7
September	51																							8									1
Iowa:																																	
June	44																			13						3	14	2	17	21			6
July	45			16	31	44	41	32	27	38	45	45	44	45	45	45	42	45	13	16			20	8	13	26	43	13	9				24
August	45		4						2	34	2	2	31	13	21	29	20	13	41	10	18	15	2	36	20	20	2	7					21
September	54						6					13																					2
Missouri:																																	
June	49									6					1	9	23	17	14	43	29	8	2	1		3	23	30	46	47	9		17
July	49	1		15	30	28	21	25	25	35	39	37	46	49	49	48	39	38	34	34	8		17	38	42	42	42	46	30	12			27
August	50			7	16	8			9	44	32	9	41	40	42	46	49	50	50	49	45	47	47	40	37	36	45	47	19			5	25
September	50	2	1		2	9	24	6	3		8	28	11	9	4	1																	13
Arkansas:																																	
June	54						2	1	3	13	3				1	13	27	31	37	51	53	47	35	8		2	10	26	47	31	26		21
July	54	4			2	1	1	4	8	12	7	9	25	43	31	22	13	17	43	25	17	2	1	8	14	12	17	26	34	30	4	1	29
August	54	1		5	11	31	20	15	23	52	50	38	34	33	34	42	49	52	51	46	46	46	45	25	5	1	31	43	49	10	2	11	30
September	54	1	4	13	21	29	14	18	18	14	27	24	20	14	12	1	1			2	2	1		1									20
Wisconsin:																																	
July	40					1	8	34	35	30	29	33	34	36	29	7	6	10	3								3	1					16
August	40									3			1			9			8	1													5
Illinois:																																	
June	48																	15		16	17	1						5	20	37	10		8
July	48				21	32	43	44	43	40	46	45	47	46	47	41	33	34	6	2			1	17	14	15	45	36	18	1			24
August	48				1	2				18	6	7	17	30	17	24	17	17	44	28	21	29	39	21	28	20	24	14	15				22
September	48											5	5	8	3																		4
Indiana:																																	
June	49																1	8			4							4	11	21	8		7
July	50				4	15	18	41	46	44	50	46	48	48	50	41	18	21	1					2	5		23	36	9				20
August	49			1	1	1				2	1	1	6	23	1	9	10	13	22	30	22	34	43	8	20	11	11	12	17	1			24
September	50	1											2	4	5	1	1																6
Ohio:																																	
June	35																	5												2	1		3
July	35							3	19	34	31	26	30	22	34	12	2	4	1								4	19	2				15
August	35													5						16	1	17	23	3									6
September	36														1																		1
Kentucky:																																	
June	41															2	1	22	2	5	11	6					4	23	31	38	24		12
July	39	1					1	22	20	36	36	31	32	34	37	37	2								4		7	19	22	1			17
August	40										1	2	4	2	1	4	9	25	28	38	33	39	33	7	5	9	19	31	32	3	1		21
September	40												2	1	6	3	1																5

TABLE 4.—*Monthly and annual temperature departures, 1936*

[Compiled from tables entitled "Climatological data for Weather Bureau stations" contained in the 12 issues of the REVIEW during 1936]

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Annual
New England	+0.1	−4.9	+7.2	−0.8	+2.1	+0.5	−0.7	+0.2	+0.2	+0.5	−2.3	+3.1	+0.4
Middle Atlantic	−2.8	−5.4	+6.5	−1.7	+2.6	+.3	+1.5	+2.1	+1.0	+1.6	−1.7	+3.4	+.7
South Atlantic	−2.4	−3.7	+3.8	−1.2	+1.9	+.9	+1.8	+2.0	+3.3	+2.8	−.7	+2.0	+.9
Florida Peninsula	+1.7	+.1	−.2	+1.3	+.3	−.6	+.7	+.2	+1.3	+2.9	+.1	+3.4	+.9
East Gulf	−1.3	−3.7	+3.8	−1.3	+1.7	+2.7	+1.1	+1.5	+3.5	+2.0	−1.2	+2.1	+.9
West Gulf	−1.8	−5.9	+4.0	−1.6	+.5	+2.6	+.5	+3.1	+2.8	−2.5	−2.9	+2.5	+.1
Ohio Valley and Tennessee	−5.6	−6.5	+4.2	−3.5	+3.0	+2.3	+3.8	+4.9	+4.1	+.4	−3.0	+3.4	+.6
Lower Lakes	−2.7	−6.9	+4.8	−2.8	+2.9	.0	+1.9	+2.2	+2.5	+.1	−3.5	+3.6	+.2
Upper Lakes	−2.5	−10.3	+3.4	−3.9	+4.3	−1.9	+4.4	+2.5	+2.6	−2.5	−3.6	+3.5	−.3
North Dakota	−10.7	−20.4	+2.8	−4.6	+7.8	+3.2	+12.3	+4.6	+3.3	−1.4	+1.4	+2.2	.0
Upper Mississippi Valley	−6.7	−12.8	+4.3	−3.4	+5.7	+.5	+8.2	+6.4	+3.9	−.8	−1.9	+4.7	+.7
Missouri Valley	−7.4	−13.2	+5.9	−1.5	+6.0	+3.9	+10.3	+8.8	+4.6	−.9	−.9	+4.4	+1.7
Northern Slope	−.2	−16.7	+1.5	−.1	+7.0	+4.7	+8.4	+4.1	+1.9	+1.6	−.4	+2.1	+1.2
Middle Slope	−.6	−8.3	+4.6	+1.2	+4.2	+4.6	+6.2	+6.6	+2.2	−1.9	+.7	+4.7	+2.0
Southern Slope	−.7	−1.6	+3.6	.0	+.6	+2.6	+.2	+3.1	+.1	−2.6	−1.9	+3.4	+.6
Southern Plateau	+1.3	+.8	+2.7	+4.1	+3.5	+3.6	+1.7	+2.2	.0	+.7	+.9	+1.6	+1.9
Middle Plateau	+3.4	+1.5	+1.4	+4.1	+4.2	+3.6	+2.9	+1.9	−.4	+1.7	−1.3	+1.4	+2.0
Northern Plateau	+2.9	−9.7	−1.6	+3.9	+5.8	+3.2	+4.2	+3.2	+.6	+4.3	−3.7	+3.5	+1.4
North Pacific	+3.9	−4.4	−1.2	+3.6	+3.7	+3.4	+2.1	+2.4	+.6	+3.2	−.2	+1.5	+1.6
Middle Pacific	+3.6	+1.3	+1.6	+2.4	+3.3	+2.6	+2.4	+1.8	+2.3	+2.9	+1.9	−.2	+2.2
South Pacific	+3.8	+.9	+1.8	+1.4	+3.1	+1.6	+3.3	+2.5	+1.8	+2.3	+4.4	+1.2	+2.8
United States	−1.2	−6.2	+3.1	−.2	+3.5	+2.1	+3.7	+3.2	+2.1	+.7	−.9	+2.7	+1.0

TABLE 5.—*Precipitation departures, monthly and annual, 1936*

[Compiled from tables entitled "climatological data for Weather Bureau stations" contained in the 12 issues of the REVIEW during 1936]

Districts	January	February	March	April	May	June	July	August	September	October	November	December	Sum
New England	+2.4	−0.5	+2.6	+0.3	−1.4	+0.8	−1.4	−0.3	+0.5	+0.4	−1.5	+3.5	+5.4
Middle Atlantic	+2.7	−.2	+1.3	.0	−1.3	+.1	−1.3	−.4	+.3	.0	−1.3	+1.7	+1.6
South Atlantic	+2.0	+.7	+1.9	+1.9	−2.4	−1.1	+.5	−.4	+.4	+2.2	−.6	+1.8	+6.9
Florida Peninsula	+.8	+3.1	+1.5	−.8	+.8	+6.1	+1.6	+1.6	−2.3	−1.1	−.1	+.2	+11.4
East Gulf	+4.8	+1.8	−2.4	+2.0	−1.4	−2.5	+1.1	.0	−1.2	−.3	−1.0	+.6	+1.5
West Gulf	−1.7	−1.4	−1.3	−.8	+2.7	−1.9	+1.4	−1.5	+1.8	−.5	−1.0	.0	−4.2
Ohio Valley and Tennessee	−.7	−.7	+.5	+.1	−2.1	−2.5	.0	−.9	+.2	+1.0	.0	+.3	−4.8
Lower Lakes	−.6	−.1	+1.7	.0	−1.5	−1.2	−1.2	−.6	+.8	.0	−.1	−.6	−3.4
Upper Lakes	+.2	.0	−.7	−.4	−.8	−1.9	−2.4	+.8	+1.4	.0	−1.1	+.3	−4.6
North Dakota	−.1	+.3	+.2	−1.2	−1.7	−2.5	−1.8	−1.2	−.5	−.9	−.3	−.2	−9.9
Upper Mississippi Valley	−.2	.0	−.3	−1.0	−2.2	−1.9	−2.6	−.1	+2.7	−.1	−.7	+.7	−5.7
Missouri Valley	+.2	−.5	−1.3	−1.3	−.8	−2.7	−3.1	−2.0	+2.1	−.6	−.8	+.3	−10.5
Northern Slope	.0	+.3	−.1	−.5	−1.2	−.6	−.5	−.3	−.5	.0	−.4	.0	−3.8
Middle Slope	−.1	−.6	−.8	−1.6	+.5	−2.1	−1.9	−1.1	+2.0	.0	−.9	.0	−6.6
Southern Slope	+.1	−.6	−.4	−.4	+2.0	−1.0	−1.0	−1.6	+2.5	−.6	−.7	−.4	−2.1
Southern Plateau	−.1	+.3	−.3	−.3	−.1	−.2	+.3	−.4	+.8	.0	−.1	+.1	.0
Middle Plateau	−.1	+1.1	−.2	−.6	−.8	+.3	+.7	+.2	−.2	+.3	−.5	+.4	+.6
Northern Plateau	+.8	+.3	−.4	−.5	−.8	+.4	+.2	.0	−.2	−.9	−1.3	−.6	−3.0
North Pacific	+2.1	−.4	−1.0	−1.4	+1.0	+1.3	+.3	−.1	−1.1	−2.9	−5.5	−.7	−8.4
Middle Pacific	+1.0	+3.6	−2.3	+.2	−.2	+.4	+.1	.0	−.6	−1.2	−3.4	−.9	−3.3
South Pacific	−1.6	+3.5	−.8	−.3	−.4	.0	.0	+.1	−.1	+1.3	−.8	+2.8	+3.7
United States	+.6	+.5	−.1	−.3	−.6	−.6	−.5	−.4	+.4	−.2	−1.0	+.5	−1.8

NOTES AND REVIEWS

Sir Napier Shaw (with the assistance of Elaine Austin). *Manual of Meteorology:* Volume II, Comparative Meteorology. Second Edition, Cambridge; at the University Press, New York; The Macmillan Co., 1936.

The *Manual of Meteorology* by Sir Napier Shaw first appeared in four large volumes during the years 1926–32 (a preliminary version of vol. IV was issued in 1919). Of these, the third and the fourth volumes are in general largely occupied with the physical and dynamical aspect of meteorology, the first volume with historical material, and the second with descriptive meteorology.

Volume II, Comparative Meteorology, which first appeared in 1928, has now, after a lapse of 8 years, appeared in a second edition, with both omissions and additions as well as corrections and modifications throughout the text, the net result of which is an increase of 35 in the number of pages. In using the volume, particular attention should be paid to the notes gathered together at the end (in ch. X), which bring information throughout the book up to date; a list of the omissions from the first edition is also included. The book comprises xlviii+472 royal octavo pages, and contains over 200 figures, including many maps and charts, numerous tables, bibliographies and references to literature, and a 20-page index.

The volume opens with 22 pages devoted to definitions and extended explanations of a number of physical and meteorological terms, followed by a 9-page discussion of meteorological nomenclature and units, and a graph that shows the duration of daylight throughout the year at different latitudes.

The first chapter briefly discusses solar and terrestrial radiation. The second chapter is a short account of the orographic features of the earth, sea ice, ocean currents, and geophysical phenomena more or less directly involved in meteorology—volcanoes, earthquakes, terrestrial magnetism, aurorae, atmospheric electricity; a map of annual frequency of days with thunder over the globe is included. Chapter III considers the composition of the atmosphere (at all heights), including the solid impurities such as dust, smoke and nuclei.

In chapter IV, the normal distribution of temperature over the globe is discussed. The principal feature of the chapter is a set of monthly and annual world maps of normal temperature reduced to sea level, supplemented by maps of the average daily range throughout the year, the seasonal range, and sea-surface temperatures. Numerous tables and diagrams are also given. Earth temperatures and upper air temperatures are discussed at length, including the distribution of potential temperature and entropy in the free air. Chapter V presents a corresponding discussion of humidity, fog, cloud, precipitation, and evaporation, accompanied by world maps of normal dewpoints, cloudiness, and rainfall. Pressure, and the surface and upper air winds of the globe, are similarly treated in chapter VI, which also includes world charts of normal pressure at 2, 4, 6, and 8 kilometers.

After this discussion of the normal state of the atmosphere as represented by monthly and annual mean values and mean diurnal and seasonal variations, it is pointed out that a mean value is not necessarily the value that actually occurs with the greatest frequency; and in chapter VII the problem of the variations from the normal which are observed to be continually in progress is considered. In this chapter is included a discussion of meteorological periodicities, with a list of periods, of from 1 to 260 years in length, which have been found in various meteorological phenomena by different writers (that occupies five pages of fine print!) and of the application of correlation theory to meteorological phenomena.

Chapters VIII and IX are devoted to cyclones and anticyclones—their general characteristics and phenomena, paths, and structure, with brief mention of tornadoes, whirlwinds, and waterspouts. A short note by E. Gold on weather forecasting is included.—*Edgar W. Woolard.*

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[RICHMOND T. ZOCH, *in Charge of Library*]

By AMY D. PUTNAM

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SOLAR OBSERVATIONS

DIFFERENCES BETWEEN AMERICAN AND EUROPEAN RESULTS FOR β AND w

By HERBERT H. KIMBALL, Research Assistant, Harvard University

In the MONTHLY WEATHER REVIEW for November 1936, page 377, I published a brief reference to differences that appear in the values of β, the atmospheric turbidity factor, as obtained at European and at American meteorological observatories, which seemed to be due largely to methods of computation or else to differences in the fundamental data on which the computations are based.

In this note I also called attention to an alleged error in the method that had been followed at the United States Weather Bureau, and later at the Blue Hill Meteorological Observatory, in computing β. Later, it was pointed out (MONTHLY WEATHER REVIEW, December 1936, p. 430) that in reality no error had been made. This confusion of thought on my part was due to the strain of overwork in keeping Blue Hill observations reduced and published on time, in addition to revising methods of reduction.

In the meantime a letter was received from Dr. Feussner, Director of the Potsdam Magnetic and Meteorological Observatory, who had been very helpful in procuring and standardizing the color screens that are used in obtaining measurements of the intensity of solar radiation in certain designated sections of the spectrum. He suggested that in the United States we adopt the system of curves which are used at European observatories and which have been sanctioned by such eminent European scientists as Ångström, Hoelper, and Süring. I readily agreed to this proposal, since a casual examination showed close agreement between these curves and those that had been computed by me, and especially since my curves were made at my home, immediately following my retirement from the Government service, where conveniences for accurate work were meagre.

The use of the European curves was to have begun with the data for January 1937; these data reached me from Blue Hill on February 3. The morning of January 1 at Blue Hill had been unusually clear; the unscreened solar radiation, expressed in units on the Smithsonian Pyrheliometric scale, at solar altitude 22°22′ (air mass, 2.61) was 1.356. Reducing this air mass by 0.2 percent on account of the reduced air pressure at the summit of Blue Hill, I found that the measured intensity falls above the curve for $\beta=0$ on the European diagram. At solar altitude 23°28′, shortly before noon on this same day, air mass 2.50, the measured intensity was 1.384. Reducing the air mass for air pressure at the summit of Blue Hill to 2.45, I found this value also falls above the curve for $\beta=0$. The corresponding values of β and w, computed from the curves published by me in the MONTHLY WEATHER REVIEW, March 1933, page 82, are as shown in table 3.

A hasty examination indicates to me that while for $m=1.0$, and $\beta=0$, the American curves for I_m give an intensity of 91.2 percent of the solar constant, the European curves give only 89.8, or a difference of 1.4 percent. The difference increases, of course, with wave length. Measurements at Blue Hill during January are most frequently made with air masses of about 2.5 to 4.0.

It seems necessary, therefore, to continue to use the American curves until an error is shown in them that will explain the above discrepancies.

SOLAR RADIATION OBSERVATIONS DURING JANUARY 1937

By IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January 1935 REVIEW, page 24.

During January 1937 at Washington there were fewer days on which normal-incidence observations were obtained than in any other month during which this type of measurements has been made, that is, since October 1914. As but one observation was made at each air mass, little may be said about the departures from normal at Washington. The observations at Madison and Lincoln were close to normal for the month, as also were those at Blue Hill, for which departures from normal are computed for the first time since the beginning of solar observations there nearly four years ago.

Table 2 shows a deficiency in the total solar and sky radiation at all stations except those on the west coast: Fresno, La Jolla, and Friday Harbor; and also the mid-Plains city of Lincoln.

Neither polarization nor turbidity determinations were made at Washington during January because of the large percentage of cloudiness.

LATE DATA

The values of the total solar and sky radiation expressed in gram calories per square centimeter for the weeks beginning December 3, 10, 17, and 24, 1936, for Fairbanks, Alaska, are 11, 5, 8, and 3 with departures of +4, 0, +2, and −2, respectively. For the year Fairbanks had a minus departure of 2,576 gram calories, or a percentage departure of 5.6.

TABLE 1.—*Solar radiation intensities during January 1937*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.				[1] 1.0	P. M.				
	e	5.0	4.0	3.0	2.0		2.0	3.0	4.0	5.0	e
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
Jan. 14	8.48							1.23	1.14	1.00	10.59
Jan. 16	10.97	0.59	0.76	1.06							2.87
Jan. 27	2.26				1.22						1.96
Means		(.59)	(.76)	(1.06)	(1.22)			(1.23)	(1.14)	(1.00)	
Departures		-.16	-.10	+.03	-.22			+.18	+.24	+.18	

LINCOLN, NEBR.

Date	8 a.m. (e)	78.7° (5.0)	75.7° (4.0)	70.7° (3.0)	60.0° (2.0)	0.0° (1.0)	60.0° (2.0)	70.7° (3.0)	75.7° (4.0)	78.7° (5.0)	Noon (e)
Jan. 5	1.12							1.16	0.97	0.85	3.15
Jan. 11	.71							1.24	1.00	.89	1.96
Jan. 12	1.07		1.03	1.20							1.68
Jan. 13	3.45							1.12	.98	.84	4.37
Jan. 14	.91	0.86		1.08							.91
Jan. 15	.71	.86	1.09	1.32				1.26	1.12	1.00	.81
Jan. 16	1.45	.89	.96								2.74
Jan. 22	.66						1.44	1.42	1.26	1.10	1.12
Jan. 23	.64		1.14	1.32	1.47						1.68
Jan. 25	.79	1.04	1.11	1.27	1.40		1.24	.97	.91	.82	1.02
Jan. 26	1.32						1.30	1.07	.84	.70	2.26
Jan. 27	2.36	.91	1.04	1.15	1.30						3.99
Means		.91	1.06	1.22	1.39		1.33	1.18	1.01	.89	
Departures		-.01	+.01	+.03	+.01		-.03	.00	-.04	-.04	

TABLE 1.—*Solar radiation intensities during January 1937*—Contd.

MADISON, WIS.

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.				[1] 1.0	P. M.				
	e	5.0	4.0	3.0	2.0		2.0	3.0	4.0	5.0	e
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
Jan. 11	1.60	0.76	0.92	1.12	1.36						1.96
Jan. 12	1.78	.92	1.01	1.11	1.34			1.02			2.06
Jan. 18	1.24	.73	1.06	1.19	1.44			1.38			1.07
Jan. 23	.46			1.09	1.46						.79
Jan. 25	1.32	.64	.77	1.01	1.22						1.19
Jan. 27	1.60				1.24			.95			2.06
Means		.76	.94	1.10	1.34			1.12			
Departures		-.19	-.11	-.11	-.01			-.03			

BLUE HILL, MASS.

Date	8 a.m. (e)	78.7° (5.0)	75.7° (4.0)	70.7° (3.0)	60.0° (2.0)	0.0° (1.0)	60.0° (2.0)	70.7° (3.0)	75.7° (4.0)	78.7° (5.0)	Noon (e)
Jan. 1	2.3	1.22	1.28	1.35	1.46						2.5
Jan. 4	2.1		.97	1.10			1.28	1.05	0.88	0.76	2.0
Jan. 5	3.2	.91	1.07	1.22	1.35					.84	2.6
Jan. 6	1.3	1.04	1.16	1.30	1.45		1.45	1.20			1.3
Jan. 11	2.3			1.12	1.32		1.35	1.16			2.2
Jan. 13	3.8	1.04	1.13	1.21	1.31		1.38	1.21	1.00		2.8
Jan. 16	2.5							.96	.88		2.4
Jan. 27	1.0			1.24	1.35				.94		1.0
Jan. 28	1.2			.96	1.15						2.1
Jan. 30	3.1				1.36		1.30	1.28	1.13		2.3
Jan. 31	3.6			1.28	1.36						2.5
Means		1.05	1.12	1.20	1.35		1.36	1.14	.97	(.80)	
Departures		+.12	+.08	+.05	+.03		+.02	-.04	-.10	-.15	

[1] Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Gram-calories per square centimeter															
	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Friday Harbor	Ithaca
1937	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Jan. 1	128	98	118	74	112	195	4	131	219	290	177	220	142	247	102	101
Jan. 8	102	121	217	81	110	214	3	152	234	274	202	211	137	357	76	78
Jan. 15	61	134	232	92	65	284	9	177	285	286	168	269	69	411	107	36
Jan. 22	102	185	277	106	120	228	24	181	297	328	152	194	143	403	81	110
	Departures from weekly normals															
Jan. 1	-46	-30	-54	-6	+8	+43	-3	-31	-12	-4	+11	-8	-3		+31	+4
Jan. 8	-70	-14	+31	-1	+2	+48	-5	-15	-26	-23	+10	-30	-10		-3	-10
Jan. 15	-121	-21	+34	-6	-44	+90	-4	-6	+7	+10	-30	+5	-96		+16	-66
Jan. 22	-101	0	+49	-13	-31	+3	-2	-6	+34	-4	-51	-73	-52		-16	-40
	Accumulated departures on Jan. 28															
	-2,366	-455	+420	-182	-455	+1,288	+98	-406	+21	-147	-420	-742	-1,127		+196	-784

ON THE METHOD EMPLOYED FOR COMPUTING β AND W, SEE P. 18 OF THIS REVIEW.—ED.

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during January 1937 and determinations of the atmospheric turbidity factor, β, and water-vapor content, w = depth in millimeters, if precipitated*

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	β_{mean}	$\frac{I_{y-o}}{1.94}$ (Percentage of solar constant)	$\frac{I_{y-o}-I_m}{1.94}$ (Percentage of solar constant)	w	Air-mass type
1937										
Jan. 1	° ′	m	gr cal.	gr cal.	gr cal.				mm	
1:17 a. m.	22 22	2.61	1.356	0.912	0.740	0.022	76.0	9.0	5.5	Pc
0:57 a. m.	23 28	2.50	1.384	.912	.748	.027	75.4	6.4	4.3	
Jan. 4										
2:04 a. m.	19 06	3.03	1.102	.692	.592	.023	73.2	18.6	10.8	NPc
Jan. 5										
2:42 a. m.	14 29	3.94	1.108	.764	.664	.058	66.7	11.5	5.6	NP
Jan. 6										
3:33 a. m.	8 35	8.88	.972	.692	.608					
1:17 a. m.	22 53	2.56	1.316	.876	.724	.047	68.2	2.6	.6	Pc
1:28 p. m.	22 10	2.63	1.204	.848	.696	.050	67.6	5.6	3.5	
Jan. 11										
1:56 a. m.	20 40	2.81	1.216	.792	.668	.050	66.0	15.1	9.1	NPc
Jan. 13										
2:14 a. m.	19 10	3.02	1.184	.784	.660	.056	64.0	.8	.5	
2:03 a. m.	20 14	2.88	1.208	.792	.664	.052	66.0	10.0	5.9	NP
3:37 a. m.	9 00	6.18	.980	.660	.560	.048	60.0	11.0	4.5	
Jan. 16										
3:01 p. m.	14 11	4.02	.879	.632						Pc
Jan. 27										
2:23 a. m.	21 46	2.68	1.256	.824	.685	.040	69.8	7.1	4.1	
0:40 a. m.	28 38	2.08	1.268	.800	.664	.088	66.4	1.6	1.1	Pc
3:12 p. m.	14 54	3.84	.968	.652	.576	.100	56.0	7.2	3.7	
Jan. 28										
3:32 a. m.	12 20	4.61	1.000	.680	.584	.090	65.0	12.3	5.8	Pc
Jan. 30										
1:38 a. m.	25 39	2.32	1.172	.752	.630	.105	60.8	2.2	1.5	Pc
0:35 p. m.	29 35	2.02	1.334	.848	.700	.055	71.5	4.8	3.4	

Atmospheric conditions during Smithsonian readings, Blue Hill Observatory, January 1937

Date	Time from local noon	° C.	Wind, Beaufort	Visibility	Sky blueness	Cloudiness and remarks
Jan. 1	1:32 a. m.	+4.9	WNW 3	8	10	1 Ci., Light to Moderate haze.
4	2:16 a. m.	−1.9	W 3	8	8	Few Acu., Light haze.
5	2:45 a. m.	0.0	SSW 5	7	8	Few Ci., Moderate haze.
6	3:36 a. m.	−7.7	NW 5	9	8	2 Ci., Light haze.
6	1:20 a. m.	−6.6	NW 3	9	8	1 Ci., Light haze.
6	1:35 p. m.	−3.9	NNW 1	9	7	3 Ci., Light haze.
11	1:59 a. m.	−3.9	NNE 1	6	8	1 Acu., Dense haze.
13	2:18 a. m.	+0.1	W 1	7	8	Few Ci., Moderate haze.
13	2:06 a. m.	+0.3	NW 1	7	8	Few Ci., Moderate haze.
16	2:28 p. m.	−0.8	NW 4	8	7	6 Cu., Light haze, Cu in front of sun.
16	2:59 p. m.	−0.6	NW 4	8	7	6 Cu., Light haze, Cu in front of sun.
27	2:26 a. m.	−9.1	NW 4	8	8	2 Cu., Light haze.
27	0:43 a. m.	−7.8	NW 4	8	8	Few Cu., Light haze.
28	3:34 a. m.	−9.1	NNE 3	5	8	1 Ci., Dense haze at low angle.
30	1:41 a. m.	−1.0	N 3	6	8	Few Cu., Dense haze.
30	0:31 p. m.	0.0	NE 3	8	8	Few Ci., Moderate haze.

POSITIONS AND AREAS OF SUN SPOTS

Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1936	h m	°	°	°				
Nov. 1	11 35	−54.0	252.9	−15.0		103		Harvard.
		−36.0	270.9	−14.0		172		
		−32.5	274.4	+20.5		63		
		−24.5	282.4	+19.5		14		
		−13.0	293.9	−19.0		40		
		−4.5	302.4	+18.5		238		
		−0.5	306.4	−24.5	14			
		+3.0	309.9	−13.0	13		657	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1936	h m	°	°	°				
Nov. 2	12 30	−68.0	225.3	+13.0	81			Mount Wilson.
		−68.0	225.3	−12.0	113			
		−50.0	243.3	−14.0		62		
		−41.0	252.3	−18.0		123		
		−24.0	269.3	−17.0		305		
		−16.0	277.3	+19.0		138		
		−2.0	291.3	−20.5	38			
		+6.0	299.3	+18.0		129		
		+14.0	307.3	−14.0		30	1,019	
Nov. 3	13 19	−56.0	223.6	+12.5	46			U. S. Naval.
		−55.0	224.6	−11.0	123			
		−37.0	242.6	−14.0		62		
		−36.0	243.6	−17.0		154		
		−25.0	254.6	−17.5		46		
		−15.0	264.6	−18.0		123		
		−8.5	271.1	−15.5		93		
		−3.0	276.6	+20.5		185		
		+11.0	290.6	−21.0	31			
		+20.0	299.6	+19.5		93		
		+29.0	308.6	−16.0		62	1,018	
Nov. 4	12 4	−83.0	184.1	+15.0	93			Do.
		−65.0	202.1	−13.0	31			
		−54.0	213.1	−14.0	15			
		−42.5	224.6	+13.0		46		
		−41.0	226.1	−11.0	123			
		−23.0	244.1	−16.5		216		
		−15.0	252.1	−17.5		93		
		−2.0	265.1	−18.0		154		
		+5.0	272.1	−15.0		93		
		+10.0	277.1	+20.0		247		
		+24.0	291.1	−21.0	31			
		+33.0	300.1	+19.0		15		
		+44.0	311.1	−15.0		31	1,188	
Nov. 5	11 22	−75.0	179.3	+14.0		309		Do.
		−62.0	192.3	−18.0		46		
		−52.0	202.3	−13.0		31		
		−39.5	214.8	−14.0	15			
		−30.0	224.3	+13.0	62			
		−29.0	225.3	−11.0	123			
		−11.0	243.3	−13.5		232		
		−9.0	245.3	−16.5		46		
		−1.0	253.3	−17.0		46		
		+10.5	264.8	−17.5		77		
		+19.0	273.3	−15.5		93		
		+20.0	274.3	+21.0		77		
		+26.5	280.8	+19.0	46		1,203	

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1936	h m	°	°	°				
Nov. 6	10 47	−69.5	172.0	+9.5		73		Harvard.
		−61.0	180.5	+15.0	219			
		−53.0	188.5	+14.5	127			
		−14.5	227.0	+13.5	53			
		−13.5	228.0	−11.0	157			
		+5.0	246.5	−12.0		153		
		+9.5	251.0	−17.0		145		
		+25.0	266.5	−17.0		57		
		+35.5	277.0	−15.0		189		
		+42.0	283.5	+18.0	34		1,207	
Nov. 7	12 15	−88.0	139.5	−20.0		429		Mount Wilson.
		−58.0	169.5	+9.0	187			
		−45.0	182.5	+14.0		445		
		−42.0	185.5	+25.0		34		
		−32.0	195.5	−16.0		51		
		−18.0	209.5	−13.0		17		
		−3.0	224.5	+14.0		56		
		0.0	227.5	−11.0	124			
		+17.0	244.5	−12.0		142		
		+21.0	248.5	−16.0		193		
		+48.0	275.5	−14.0		348		
		+53.0	280.5	+20.0	45		2,071	
Nov. 8	12 15	−44.0	170.3	+10.0	211			Harvard.
		−35.0	179.3	+15.0	191			
		−26.0	188.3	+14.5	258			
		+11.5	225.8	+13.5	49			
		+14.0	228.3	−11.0	157			
		+31.0	245.3	−12.0		44		
		+39.0	253.3	−17.0		68		
		+63.0	277.3	−14.5		294	1,272	
Nov. 9	11 6	−70.0	131.7	−10.0		494		U. S. Naval.
		−55.0	146.7	−20.5		247		
		−40.0	161.7	−20.0		247		
		−31.5	170.2	+9.0	201			
		−23.0	178.7	+13.0	93			
		−16.0	185.7	+12.0	216			
		−7.0	194.7	−17.5		15		
		+23.0	224.7	+14.0	31			
		+26.0	227.7	−11.0	77			
		+42.0	243.7	−12.0	31			
		+51.0	252.7	−18.0	31			
		+78.0	279.7	−15.0		123	1,806	
Nov. 10	11 56	−56.0	132.1	−9.0		679		Do.
		−41.0	147.1	−20.0		247		
		−26.0	162.1	−20.0		309		
		−19.0	169.1	+9.5	201			
		−10.0	178.1	+14.0	93			
		−1.0	187.1	+13.0	247			
		+28.0	216.1	−14.0	15			
		+37.0	225.1	+14.0	8			
		+39.5	227.6	−11.0	93			
		+57.0	245.1	−13.0	23			
		+65.0	253.1	−19.0	23		1,938	
Nov. 11	10 58	−43.0	132.4	−9.0		772		Do.
		−42.0	133.4	−15.0		123		
		−30.0	145.4	−20.0		247		
		−14.0	161.4	−20.0		309		
		−5.0	170.4	+9.0	154			
		+3.0	178.4	+14.0	93			
		+12.0	187.4	+13.0	247			
		+51.0	226.4	−11.0	93		2,038	
Nov. 12	12 0	−30.0	131.7	−15.0		326		Mount Wilson.
		−29.0	132.7	−8.0		917		
		−16.0	145.7	−20.0		226		
		−12.0	149.7	+12.0		4		
		+3.0	164.7	−19.0		359		
		+10.0	171.7	+10.0	150			
		+23.0	184.7	+14.0		377		
		+36.0	197.7	−15.0		118		
		+52.0	213.7	−34.0	12			
		+56.0	217.7	−12.0		8		
		+65.0	226.7	−10.0	125			
		+66.0	227.7	+23.0		8	2,630	
Nov. 13	11 5	−16.0	133.0	−9.0		617		U. S. Naval.
		−15.0	134.0	−15.0		278		
		−2.0	147.0	−20.0		185		
		+13.0	162.0	−20.0		309		
		+21.0	170.0	+10.0	154			
		+30.5	179.5	+15.0	77			
		+39.0	188.0	+13.0		247		
		+47.0	196.0	−16.0		46		
		+79.0	228.0	−11.5	62		1,975	
Nov. 14	11 16	−3.0	132.7	−9.5		494		Do.
		−2.5	133.2	−15.0		123		
		+10.0	145.7	−20.0		123		
		+25.0	160.7	−20.0		216		
		+36.0	171.7	+10.0	123			
		+45.0	180.7	+15.0	62			
		+53.0	188.7	+13.0		185		
		+58.0	193.7	+19.0		46	1,372	
Nov. 15	12 38	+8.0	129.8	−14.5	78			Harvard.
		+11.0	132.8	−6.5		356		
		+13.5	135.3	−14.0	26			
		+15.0	136.8	−9.5		65		
		+25.0	146.8	−18.5		86		
		+44.0	165.8	−19.0		223		
		+51.0	172.8	+10.5	121			
		+59.0	180.8	+14.0	50			
		+67.0	188.8	+13.0	127			
		+73.5	195.3	+20.0		96	1,228	
Nov. 16	11 51	+23.0	132.1	−15.5		77		U. S. Naval.
		+24.0	133.1	−9.5		370		
		+38.5	147.6	−20.0		154		
		+55.0	164.1	−20.5	201			
		+56.0	165.1	−29.5	46			

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1936	h m	°	°	°				
Nov. 16	11 51	+62.0	171.1	+10.5	77			
		+80.0	189.1	+11.0	62		987	
Nov. 17	11 2	−66.0	30.3	−21.0		139		U. S. Naval.
		+37.0	133.3	−9.0		432		
		+37.0	133.3	−15.0		62		
		+50.0	146.3	−20.0		93		
		+65.0	161.3	−23.0	123			
		+69.0	165.3	−20.0		154		
		+70.0	166.3	−26.5	93			
		+78.0	174.3	+10.0	46		1,142	
Nov. 18	12 2	−52.0	30.6	−21.0		309		Do.
		+50.5	133.1	−9.5		185	494	
Nov. 19	13 23	−37.0	31.7	−21.0		432		Do.
		+65.0	133.7	−9.5		185	617	
Nov. 20	13 15	−24.0	31.6	−22.0		501		Mount Wilson.
		+78.0	133.6	−7.0		130	631	
Nov. 21	12 15	−9.0	33.9	−22.0		439	439	Do.
Nov. 22	13 43	+5.0	33.9	−22.0		617	617	U. S. Naval.
Nov. 23	11 19	−78.0	299.1	+16.0	93			Do.
		+14.0	31.1	−22.0		772	865	
Nov. 24	11 39	−65.0	298.7	+15.0	185			Do.
		+27.0	30.7	−21.0		926	1,111	
Nov. 25	11 24	−51.5	290.2	−11.0		185		Do.
		−49.0	301.7	+16.5		401		
		+41.0	31.7	−21.0		988	1,574	
Nov. 26	12 30	−74.0	262.9	−13.0		1,381		Mount Wilson.
		−38.0	298.9	−11.0		602		
		−36.0	300.9	+18.0		1,025		
		−33.0	303.9	+24.0		7		
		+35.0	11.9	−9.0		8		
		+59.0	35.9	−23.0		950	3,973	
Nov. 27	13 18	−80.0	243.3	+16.0	31			U. S. Naval.
		−58.0	265.3	−15.5		1,019		
		−22.0	301.3	−11.0		741		
		−21.5	301.8	+22.0		123		
		−21.0	302.3	+17.0		1,080		
		+62.0	25.3	−24.0		62		
		+73.0	36.3	−21.0	247		3,303	
Nov. 28	12 40	−65.0	245.4	+15.0		550		Mount Wilson.
		−63.0	247.4	−18.0		45		
		−48.0	262.4	−17.0		1,860		
		−20.0	290.4	+14.0		62		
		−10.0	300.4	+16.0		1,474		
		−9.0	301.4	−12.0		659		
		−8.0	302.4	+22.0		58		
		+16.0	326.4	−18.0		7		
		+57.0	7.4	+18.0		15		
		+62.0	12.4	−8.5		37		
		+88.0	38.4	−20.5		220	4,987	
Nov. 29	12 50	−71.0	226.2	−10.5	3			Do.
		−52.0	245.2	+16.0		449		
		−49.0	248.2	−16.0		96		
		−33.0	264.2	−15.0		1,355		
		−5.0	292.2	+14.0		28		
		+3.0	300.2	+17.0		1,242		
		+5.0	302.2	−12.0		545		
		+8.0	305.2	+22.0	12			
		+70.0	7.2	+18.0		12		
		+80.0	17.2	−10.0	5		3,747	
Nov. 30	11 48	−40.0	244.6	+17.0		556		U. S. Naval.
		−35.0	249.6	−16.0		93		
		−22.0	262.6	−16.0		1,173		
		−14.0	270.6	+20.0		31		
		−10.5	274.1	−16.0		154		
		+8.0	292.6	+15.0		31		
		+18.0	302.6	−11.0		340		
		+19.0	303.6	+17.0		895	3,273	
Mean daily area for 30 days							1,681	
Dec. 1	11 10	−80.0	191.7	+21.0		247		Do.
		−80.0	191.7	+14.0	62			
		−70.0	201.7	−36.0		185		
		−69.0	202.7	−30.0	15			
		−26.0	245.7	+18.0		586		
		−20.5	251.2	−16.0		216		
		−9.0	262.7	−16.0		895		
		+3.0	274.7	−16.0		247		
		+32.0	303.7	+16.0		710		
		+36.0	307.7	−10.5		170	3,333	
Dec. 2	13 30	−61.0	196.3	+23.0	129			Mount Wilson.
		−60.0	197.3	+20.0	183			
		−60.0	197.3	+13.0		114		
		−60.0	197.3	−36.0		234		
		−43.0	214.3	−30.0		38		
		−29.0	228.3	−10.5	39			
		−10.0	247.3	+16.0		720		
		−5.0	252.3	−16.0		86		
		+6.0	263.3	−16.0		1406		
		+15.0	272.3	+18.0		6		
		+44.0	301.3	+15.0		858		
		+49.0	306.3	−12.0		215		
		+56.0	313.3	−18.0		71	4,099	
Dec. 4	13 13	−38.5	192.6	+23.5	130			U. S. Naval.
		−36.0	195.1	+20.0	93			
		−35.0	196.1	+14.0		46		
		−35.0	196.1	−36.0		123		
		−16.0	215.1	−30.0		46		
		+14.0	245.1	+17.0		494		
		+21.0	252.1	+18.0	154			
		+32.0	263.1	−16.0		679		
		+75.0	306.1	+15.5		309		
		+78.0	309.1	−11.0		93	2,176	

POSITIONS AND AREAS OF SUN SPOTS—Continued.

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1936	h m	°	°	°				
Dec. 5	11 2	−25.5	193.6	+22.5	154			U. S. Naval.
		−24.0	195.1	+20.0	108			
		−22.0	197.1	−36.0		77		
		−21.0	198.1	+13.0		46		
		−4.5	214.6	−30.0		31		
		+25.0	244.1	+16.0		556		
		+34.5	253.6	+17.0	139			
		+39.5	258.6	+26.0	31			
		+44.0	263.1	−17.0		617		
		+82.0	301.1	+12.5	93		1,852	
Dec. 6	13 10	−55.0	149.6	+11.5		21		Mount Wilson.
		−28.0	176.6	+9.0	28			
		−12.0	192.6	+23.0	129			
		−11.0	193.6	+20.0	83			
		−8.0	196.6	+13.0	57			
		−8.0	196.6	−35.0		143		
		+10.0	214.6	−30.0		16		
		+17.0	221.6	+21.0		21		
		+40.0	244.6	+17.0		974		
		+48.0	252.5	−25.0		7		
		+51.0	255.6	+26.0	14			
		+52.0	256.6	−16.0		2		
		+57.0	261.6	−14.0		497	1,992	
Dec. 7	16 10	−39.0	150.8	+13.0		11		Do.
		−12.0	177.8	+10.0	6			
		+3.0	192.8	+24.0	150			
		+4.0	193.8	+21.0	66			
		+7.0	196.8	−35.0	110			
		+8.0	197.8	+13.0	21			
		+11.0	200.8	−12.0		39		
		+25.0	214.8	−28.0	6			
		+54.0	243.8	+17.0		887		
		+72.0	261.8	−14.0		332	1,628	
Dec. 8	11 19	−61.0	118.4	−21.0	15			U. S. Naval.
		−31.0	148.4	+12.0		154		
		+12.0	191.4	+23.0		123		
		+14.5	193.9	+20.5	46			
		+19.0	198.4	+13.5		31		
		+19.0	198.4	−35.5	77			
		+22.0	201.4	−11.0		46		
		+68.0	247.4	+17.0		1,049		
		+84.0	263.4	−16.0		278	1,819	
Dec. 9	14 0	−69.0	95.8	−23.0		12		Mount Wilson.
		−47.0	117.8	−21.0		104		
		−16.0	148.8	+13.0		196		
		+13.0	177.8	+13.0		6		
		+28.0	192.8	+23.0		146		
		+29.0	193.8	+21.0	79			
		+32.0	196.8	−33.0	150			
		+34.0	198.8	+16.0		66		
		+41.0	205.8	−10.0		22		
		+49.0	213.8	−28.0		6		
		+80.0	244.8	+18.0		692	1,479	
Dec. 10	13 45	−58.0	93.7	−22.0	5			Do.
		−34.0	117.7	−20.0		180		
		−3.0	148.7	+14.0		276		
		+41.0	192.7	+24.0		110		
		+43.0	194.7	+21.0	55			
		+44.0	195.7	−34.0	137			
		+48.0	199.7	+15.0	21			
		+53.0	204.7	−10.0		43		
		+68.0	219.7	+28.0		3	830	
Dec. 11	15 0	−77.0	60.9	−22.0		294		Do.
		−45.0	92.9	−22.0		3		
		−20.0	117.9	−19.0		142		
		+13.0	150.9	+15.0		147		
		+28.0	165.9	+10.0		27		
		+56.0	193.9	+24.0		123		
		+56.0	193.9	+22.0	73			
		+57.0	194.9	−34.0		122		
		+61.0	198.9	+14.0	10			
		+66.0	203.9	−11.0	4			
		+81.0	218.9	+28.0	7		952	
Dec. 12	12 0	−65.0	61.3	−22.0		368		Do.
		−5.0	121.3	−20.0		72		
		+24.0	150.3	+14.0		108		
		+41.0	167.3	+10.0		132		
		+69.0	195.3	+24.0	79			
		+69.0	195.3	+21.0	58			
		+70.0	196.3	−34.0		175	992	
Dec. 13	12 46	−83.0	29.7	−21.0	93			U. S. Naval.
		−51.0	61.7	−21.5		340		
		+4.0	116.7	−20.0		62		
		+36.0	148.7	+14.0	23			
		+41.0	153.7	+14.0	15			
		+56.0	168.7	+10.0		123		
		+80.0	192.7	+23.0	62			
		+80.0	192.7	+20.0	54			
		+83.0	195.7	−34.0	77		849	
Dec. 14	11 19	−69.5	30.8	−20.5	123			Do.
		−39.0	61.3	−21.0		370		
		+15.5	115.8	−20.5		93		
		+48.0	148.3	+14.0	31			
		+70.0	170.3	+10.0	46		663	
Dec 16	9 51	−45.0	29.8	−22.0		152		Harvard.
		−12.5	62.3	−21.0		272		
		+38.0	112.8	−20.5		117	541	
Dec. 17	11 9	−30.0	30.9	−21.0	123			U. S. Naval.
		+0.5	61.4	−21.0		278		
		+52.0	112.9	−20.5		185	586	
Dec. 18	11 40	−18.0	29.5	−21.0	123			Do.
		+13.0	60.5	−21.0		247		
		+65.0	112.5	−21.0		123	493	

POSITIONS AND AREAS OF SUN SPOTS—Continued.

Date	Eastern standard time	Heliographic: Diff. in longitude	Heliographic: Longitude	Heliographic: Latitude	Area: Spot	Area: Group	Total area for each day	Observatory
1936	h m	°	°	°				
Dec. 20	11 30	−80.0	301.2	+16.0		29		Mount Wilson.
		−76.0	305.2	+20.0	13			
		−60.0	321.2	−26.0		36		
		−55.0	326.2	+24.0		194		
		−1.0	20.2	−25.0		11		
		+8.0	29.2	−23.0		164		
		+41.0	62.2	−21.0		144		
		+78.0	99.2	+12.0		130	721	
Dec. 21	11 16	−80.0	288.2	−29.0	62			U. S. Naval.
		−64.0	304.2	+19.0		370		
		−43.0	325.2	−24.0		62		
		−42.0	326.2	+25.0		432		
		+14.5	22.7	+17.5		93		
		+21.0	29.2	−21.0	123			
		+55.0	63.2	−20.5		93	1,235	
Dec. 22	11 19	−68.0	287.0	−29.5	93			Do.
		−50.0	305.0	+19.0		309		
		−31.0	324.0	−24.5		62		
		−28.0	327.0	+24.0		340		
		+21.0	16.0	−21.5		93		
		+27.0	22.0	+17.5		108		
		+34.5	29.5	−21.0	123		1,128	
Dec. 23	11 28	−80.0	261.7	−13.0	31			Do.
		−56.0	285.7	−28.5		185		
		−42.0	299.7	+36.0		108		
		−36.0	305.7	+19.0		278		
		−16.0	325.7	−23.0	31			
		−14.0	327.7	+24.5		340		
		+39.0	20.7	−24.0		93		
		+41.0	22.7	+16.0		62		
		+48.0	29.7	−21.0	123		1,251	
Dec. 24	11 20	−79.0	249.6	+18.0	185			Do.
		−66.0	262.6	+14.0	31			
		−65.0	263.6	−14.5		31		
		−42.0	286.6	−29.5	123			
		−40.5	288.1	−15.0		62		
		−36.0	292.6	+18.0	31			
		−29.0	299.6	+36.0		77		
		−29.0	299.6	+18.0	62			
		−21.0	307.6	+18.0	93			
		−1.0	327.6	+25.0		340		
		+51.0	19.6	−22.0		46		
		+61.0	29.6	−21.0	93		1,174	
Dec. 26	11 3	−50.0	252.4	+18.5	185			Do.
		−38.0	264.4	−15.0	31			
		−36.0	266.4	+13.0	31			
		−16.0	286.4	−29.5	123			
		−14.0	288.4	+19.5	77			
		−9.0	293.4	+19.0		93		
		−2.0	300.4	+19.5	62			
		+21.0	323.4	+22.5		123		
		+31.0	333.4	+21.5	123		848	
Dec. 28	11 0	−79.0	197.1	−10.0	123			Do.
		−68.0	208.1	+16.0	31			
		−23.0	253.1	+19.0		185		
		−10.5	265.6	+11.0		247		
		+9.0	285.1	−30.5		93		
		+15.0	291.1	+18.0		93		
		+21.0	297.1	+18.0	31			
		+49.0	325.1	+23.0		93		
		+59.0	335.1	+22.5	185		1,081	
Mean daily area for 23 days							1,379	

PROVISIONAL SUN-SPOT RELATIVE NUMBERS, JANUARY 1937

[Dependent alone on observations at Zurich and its station at Arosa]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

January 1937	Relative numbers	January 1937	Relative numbers	January 1937	Relative numbers
1	145	11	*d* 97	21	*WEEccc* 127
2	*a* 163	12	91	22	163
3	*a* 109	13	*Wc* 80	23	155
4	*Mc* 112	14	91	24	*abdd* 178
5	*a* ---	15	---	25	*Mac* 181
6	*MEcc* 82	16	*Mac* 108	26	*Ebcd* 200
7	94	17	*Eacd* 108	27	*Ec* 180
8	---	18	112	28	210
9	97	19	---	29	*Mcd* ---
10	*Mcd* 85	20	*Ec* 128	30	*ab* 233
				31	*ab* 233

Mean, 26 days=137.0.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity; E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By L. P. HARRISON

Beginning with January 1937, the monthly tables of aerological data obtained from airplane weather observations are extended to include three meteorological elements not previously presented in this REVIEW. In addition to mean free-air temperatures and relative humidities, with their departures from "normal", there are now given mean free-air specific humidities, barometric pressures, and equivalent potential temperatures.

Because of the falling off in the numbers of observations at higher levels, the monthly mean free-air temperatures, relative humidities, and barometric pressures are computed by a procedure equivalent to the method of differences. Monthly mean specific humidities and equivalent potential temperatures are computed by this same method only when the number of observations available at the surface is less than 15. That is, the arithmetic mean of the surface data for the month is first obtained, and the monthly means for the respective free-air standard levels are derived by successively applying to the former mean the mean differences between the available observational data for adjacent standard levels. When the number of observations is 15 or more at the surface, the "mean" specific humidities and equivalent potential temperatures are obtained directly from the monthly mean temperatures, relative humidities, and barometric pressures (as found in the manner just described) for the corresponding levels by the following procedure:

The saturation vapor pressure corresponding to the monthly mean temperature is multiplied by the monthly mean relative humidity, expressed decimally, and the result is regarded as the "monthly mean vapor pressure." With the latter and the mean barometric pressure as arguments, there is found by reference to an adiabatic chart the corresponding specific humidity, which then is regarded as the monthly mean of that element. By subtraction of the former of the two preceding arguments from the latter, there the partial pressure of dry air is computed. Using this as one argument and the monthly mean temperature as the other, the corresponding "partial potential temperature" is determined by reference to the adiabats on an adiabatic chart and is regarded as the mean for the month. Finally, by reference to a Rossby diagram, with the value last mentioned and the specific humidity as arguments, the corresponding equivalent potential temperature is found and considered as the appropriate monthly mean.

A slight error is inherent in this method, because of the use of specific humidity (grams of water vapor per kilogram of moist air) instead of mixing ratio (grams of water vapor per kilogram of dry air) which is one of the arguments on the Rossby diagram. Furthermore, the socalled monthly mean specific humidities and equivalent potential temperatures found in the manner just described may differ by slight amounts from the means of these elements that would be found by the method of differences. It may be mentioned that daily values of specific humidity and equivalent potential temperature are obtained by the same procedure as just outlined for monthly values, except that daily values of temperature, relative humidity, and barometric pressure are used as the basic arguments.

"Departures from normal" are given for temperature and relative humidity only. "Normals", beginning with the data for this month, are computed by taking the arithmetic mean of the monthly means for the calendar month in question during the past and current years of observations, except when the number of observations in any given month is less than 15, in which case the data therefor are left out of consideration. "Normals" prior to this time were computed by the method of differences, taking all observations into consideration. Thus in the past, the weight of each month's data in determining the "normal" was dependent upon the number of observations available during that month at the level in question; now the weight of each month's data is unity except when the number of observations is less than 15, when the weight becomes zero. "Normals" computed by the two methods under consideration may differ from one another by as much as 2° C. in temperature and 5 percent in relative humidity when observations are few in number.

It will be noted that many of the "normals" are based on only 3 years of observations. "Departures from normal" in such cases must be regarded as having little weight in comparison with departures from normals based on much more extended periods of record. Conclusions derived from such "normals" must be used with caution.

The mean surface temperatures for January (see chart I) were generally above normal in the eastern third of the country, including the west Gulf coast. The mean temperatures in the remainder of the country were generally below normal at the surface. The largest positive departures at the surface were largely concentrated in the eastern two-thirds of the area first mentioned and ranged from about +4° C. to +8° C. The largest negative departures at the surface were largely concentrated over the Western Plateau region, especially in the northern and southwestern portions thereof, and ranged from about −5° C. to −12° C.

The mean free-air temperatures for the month up to 5 kilometers above sea level (see table 1) showed essentially the same characteristics as were in evidence at the surface. Marked positive departures of from +3° C. to nearly +6° C. predominated along the northeastern Atlantic and Gulf coastal regions of the country, while slightly more pronounced departures of the opposite sign occurred in the northwestern and southwestern sections of the country (note Billings, Mont., and San Diego, Claif., respectively).

Table 3 shows the monthly mean barometric pressures and equivalent potential temperatures. Over the country as a whole, the lowest pressures prevailed in the north-central portion at all elevations up to 5 kilometers above sea level, with a center near Fargo, N. Dak. The highest pressures prevailed along the Atlantic coast, with one center over the northeast in the stratum up to nearly v.5 kilometer, and with another more pronounced center cver the extreme southeast (Miami, Fla.) that had a lertical extent from 1 to more than 5 kilometers above sea level. The monthly mean isobars in the lower 2 kilometers over the northeast coastal region showed a pronounced anticyclonic curvature and ran roughly parallel to the coast, thus giving further evidence of the westward extension of the Atlantic HIGH in that area. The trend of the isobars showed conditions favorable for a drift of warm, moist air from the Gulf of Mexico and from the southwestern part of the country toward the Gulf of St. Lawrence, and also for a drift of cold, dryer air from the northwestern part of the country toward the southeast, recurving to the northeast near the central portion. The

trend of the isobars also indicated a situation conducive to a strong drift of cold air from the north and northwest along the Pacific coast.

Table 2 shows the monthly mean free-air relative humidities and specific humidities. With the exception of the stratum near the ground in the northwest, the relative humidities in the western third of the country were generally above normal in a marked degree, with the most pronounced positive departures (+17 to +23 percent) occurring at San Diego, Calif., from about 1 to 3 kilometers above sea level. The region characterized by this regime of excessive relative humidity coincided very closely with that previously noted as having had the most markedly deficient temperatures in the country during the month. From comparison with the data for surrounding stations, the relative humidities at Salt Lake City, Utah, appeared strikingly in excess of normal, especially at elevations from 2.5 to 5 kilometers above sea level. Slight negative departures from normal relative humidity generally prevailed in the central portion of the country, except in the extreme north at the higher elevations where the opposite was true, and in the extreme south at all elevations where rather large positive departures were in evidence (note San Antonio, Tex., +7 to +15 percent from 1.5 to 5 kilometers). In the lower strata, the southeastern section of the country as far north as Washington, D. C., was characterized by relative humidities moderately in excess of normal, especially near the northeast Gulf coast where the greatest departures occurred. Otherwise, the eastern third of the country appeared to be subject to preponderantly subnormal relative humidities, most notably in the northeast section at moderate elevations. This statement may require qualification and be open to question, however, inasmuch as many aerological observations were missed at stations in the area under consideration, and the days on which they were missed were generally days with low ceilings and perhaps precipitation; the statement, moreover, is not consistent with the occurrence of precipitation during the month appreciably in excess of normal for that area. On the other hand, the dominance of the Atlantic HIGH during the month may have caused somewhat more than the usual proportion of subsiding dry air from upper elevations over the Atlantic to flow along the coastal region (*cf.* discussion of mean barometric pressures).

In general, data on mean humidity may be regarded as open to question when the number of observations during a month falls appreciably below about five-sixths of the number of days in the month (the inconsistent values for Maxwell Field, Montgomery, Ala., at 4 and 5 kilometers, based on 14 or less observations, are an illustration).

Table 4 shows the free-air resultant winds based on pilot balloon observations made near 5 a. m. (75th meridian time) during the month of January. In general, the disposition of the resultant winds bears out the statements already made on the basis of the mean pressure distribution during the month. Along the south Pacific coast region the resultant winds were somewhat in excess of normal velocity and nearly normal in direction. This condition was most pronounced near Oakland Calif., where at the levels from 2.5 to 4 kilometers the monthly resultant velocities exceeded the normals by 5.6 to 12.2 meters per second. Near the State of Washington the resultant winds were generally oriented from about 180° to 45° clockwise with respect to normal, i. e., they were directed more from the north than from the south and west as usually is the case, but with slightly deficient velocities.

In the Rocky Mountain Plateau region the resultant winds were near normal in direction but slightly subnormal in velocity in the northeast portion and somewhat supernormal in the central and southern portions, especially at Albuquerque, N. Mex., at 3 and 4 kilometers above sea level where the departures were +4.3 to +7.2 m. p. s.

As to the Mississippi Valley, in the southern portion the resultant directions were oriented from about 45° to 90° counterclockwise from normal (i. e., more from the southerly quadrant than usual), while toward the northward the counterclockwise orientations became less pronounced until they were substantially zero in the extreme north. Departures from normal velocity in this region were generally inconsequential, except in the southeast near the Gulf of Mexico where positive departures from about +3 to +6 m. p. s. prevailed in the lower kilometer. At Key West, Fla., the resultant directions were normal up to 1.5 kilometers, but from 2 to 3 kilometers the resultant winds were oriented from 67° to 141° counterclockwise with respect to normal (i. e., more from the east than south and west), while the velocities were in excess of normal by +5.2 m. p. s. at 2 kilometers, dropping to about normal at 3 kilometers.

In the northeast, the resultant directions were approximately normal, except in the very lowest stratum of nearly a kilometer where they were oriented from 45° to 70° clockwise from normal at several stations. Resultant velocities were moderately below normal. Consideration of the individual wind data for the northeast coastal region discloses the fact that there was a somewhat more than normal occurrence of easterly winds during the month at least in the stratum from 0.5 to 1 kilometer above sea level or slightly higher, in conformity with the circulation to be expected along the coast under the influence of the extraordinarily predominant Atlantic HIGH.

At Sault Ste. Marie, Mich., up to 2 kilometers above sea level, the resultant winds were oriented from about 30° to 180° counterclockwise with respect to normal and had velocities moderately in excess of the usual values.

Table 5, which is included herein for the first time, shows the maximum wind velocities for the month, together with the dates of occurrence and directions from which observed, for the three strata extending from zero to 2,500 meters, 2,500 to 5,000 meters and above 5,000 meters (mean sea level), respectively. These data are shown for nine different sections of the country. The area included in each section is indicated in the footnotes below the table. The particular station at which the maximum velocity occurred in each section is also given. It will be noted that the maximum velocity for the lower layer was 43.8 m. p. s. from the southwest at Knoxville, Tenn.; while for the intermediate layer it was 54.0 m. p. s. from the north northwest at Oakland, Calif.; and for the layer above 5,000 meters, 65.0 m. p. s. from the west southwest at Rock Springs, Wyo.

With respect to monthly mean specific humidities and equivalent potential temperatures, detailed discussion will be omitted in the absence of comparative data; however, it may be remarked that the outline of the general circulation over the country inferred above from the barometric and wind data is generally confirmed by the distribution of these elements if we regard them as approximately conservative and consider that the monthly mean trajectories of the air from various sources must therefore be marked out by the lines of constant value of the elements in question, especially the equivalent potential temperature.

The meteorological phenomena during the month, which caused the abnormal conditions summarized above, were distinctly unusual in many respects. The North Pacific HIGH extended much farther north and was more strongly developed than ordinarily is the case in January; under this influence, the flow of cold P_P air southward along the Pacific coast was considerably in excess of normal, and numerous offshoots of the North Pacific HIGH moved slowly inland across the western coastal region. In addition, shallow outbreaks of cold P_C air occurred farther westward than usual over the Pacific Northwest States and adjoining areas; while very extensive high pressure systems, formed from relatively cold and shallow P_C air overlain by quite cold P_P or N_{PP} air, frequently moved down over the Western and North Central parts of the country as far south as southern Texas and neighboring regions. These conditions gave rise to deficient precipitation in the Northwest and parts of the Southwest, as well as to severe freezes throughout the far West with damage to agricultural interests that was especially great in California.

The frequent high pressures which were prevalent in the neighborhood of the Southeastern Plateau region probably contributed to the flow of moist N_{PP} air, from the oceanic area near the extreme south of the California coast northeastward to the Great Basin, with the occurrence of slightly above-normal precipitation over the latter area and central California.

In contrast to the usual drift of the cold P_C and P_P air masses toward the east, their drift during January after having reached their greatest southern extent was generally northeastward with pronounced recurvature. As these air masses spread out farther to the east, cyclonic waves frequently developed along their southern and southeastern peripheries and moved northeast along the region contiguous to and especially to the east of the lower Mississippi and Ohio Rivers.

The Atlantic HIGH was displaced much farther to the west, and was more intensely developed, than normally, during a considerable portion of the month. This was undoubtedly a contributory factor to the abnormal recurvature of the cold air masses and the frequent formation of cyclonic waves just referred to, because warm moist air from the Gulf of Mexico was impelled, to an extraordinary degree, to push northward against the wedges of cold air, and produced the almost unprecedented heavy precipitation and warm weather which were experienced in the eastern half of the country. In the central Mississippi and Ohio River Valleys the precipitation for the month reached remarkable totals of from 200 to 400 percent of the normal, with the consequent development of disastrous floods in that region.

TABLE 1.—*Mean free-air temperatures (t), in °C. obtained by airplanes during January 1937. (Dep. represents departure from "normal" temperature)*

Stations	Altitude (meters) m. s. l.																		
	Surface			500		1,000		1,500		2,000		2,500		3,000		4,000		5,000	
	Number of obs.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.	t	dep.
Barksdale Field [1] (Shreveport), La. (52 m)	16	9.8	......	9.8	......	10.2	......	8.2	......	7.0	......	4.9	......	2.8	......	−2.2	......	......	......
Billings, Mont. [2] (1,089 m)	30	−16.2	−6.3	......	......	......	......	−14.4	−7.6	−15.2	−7.9	−15.6	−6.4	−17.4	−5.6	−22.5	−4.7	−29.4	−4.6
Boston, Mass. [1] (5 m)	19	1.3	+1.7	0.7	+2.6	−0.7	+2.6	−0.1	+3.6	−1.1	+3.7	−2.3	+4.3	−4.1	+4.8	−9.4	+4.7	......	......
Cheyenne, Wyo. [2] (1,873 m)	31	−12.3	−5.3	......	......	......	......	......	......	−11.2	−5.4	−10.4	−5.0	−11.7	−4.2	−17.7	−3.8	−24.3	−3.4
El Paso, Tex. [2] (1,194 m)	31	1.6	......	......	......	......	......	5.0	......	3.2	......	1.2	......	−1.0	......	−5.4	......	−10.9	......
Fargo, N. Dak. [2] (274 m)	30	−22.3	−1.3	−21.0	−1.5	−16.7	−1.4	−15.0	−2.1	−14.8	−2.2	−16.1	−2.3	−18.0	−2.3	−22.6	−1.7	−29.3	−1.5
Kelly Field (San Antonio), Tex. [1] (206 m)	18	8.3	+1.3	11.0	+0.7	10.8	0.0	10.4	0.0	9.7	+0.6	8.0	+0.9	5.6	+1.2	−1.3	+0.2	−8.5	−0.2
Lakehurst, N. J. [3] (39 m)	17	2.2	......	0.9	......	−0.1	......	1.3	......	0.7	......	−0.2	......	−2.1	......	−8.0	......	......	......
Maxwell Field (Montgomery), Ala. [1] (52 m)	14	15.8	......	14.6	......	13.6	......	11.0	......	9.5	......	8.0	......	6.0	......	0.9	......	−5.1	......
Miami, Fla. [2] (4 m)	30	21.0	......	20.5	......	16.3	......	14.3	......	12.9	......	11.0	......	9.0	......	3.3	......	−2.7	......
Mitchel Field (Hempstead, L. I.), N. Y. [1] (29 m)	18	0.9	+3.4	0.6	+3.6	0.4	+4.5	0.8	+5.1	0.6	+5.9	−0.6	+5.8	−2.6	+5.8	−6.7	+6.7	−14.2	+5.6
Murfreesboro, Tenn. [2] (174 m)	29	8.2	+5.4	7.6	+4.7	8.1	+5.0	7.1	+4.2	5.7	+3.8	3.8	+3.8	1.7	+3.9	−3.9	+3.3	−9.7	+3.5
Norfolk, Va. [3] (10 m)	5	10.6	......	10.4	......	8.9	......	6.1	......	5.7	......	4.9	......	2.4	......	−3.5	......	−9.3	......
Oakland, Calif. [3] (2 m)	30	3.3	......	3.5	......	0.9	......	−1.1	......	−2.9	......	−4.7	......	−7.0	......	−12.4	......	−18.6	......
Oklahoma City, Okla. [2] (391 m)	27	−1.0	−1.0	−0.8	−1.4	2.0	−1.7	3.0	−0.8	1.6	−0.6	−0.1	−0.3	−2.1	+0.5	−7.6	+1.0	−14.6	+0.8
Omaha, Nebr. [2] (300 m)	31	−14.7	−6.5	−14.0	−6.9	−10.9	−6.7	−7.6	−5.1	−7.8	−4.5	−9.4	−4.0	−11.7	−3.7	−17.6	−3.6	−24.4	−3.8
Pensacola, Fla. [3] (13 m)	23	18.0	+6.7	16.8	+5.5	15.3	+5.3	12.6	+3.7	10.3	+3.6	9.5	+4.1	7.2	+4.7	1.7	+4.5	−3.8	+5.0
St. Thomas, V. I. [3] (8 m)	26	23.4	......	21.4	......	18.6	......	15.8	......	13.6	......	11.7	......	9.5	......	4.2	......	−1.8	......
Salt Lake City, Utah [2] (1,288 m)	31	−11.2	......	......	......	......	......	−8.0	......	−8.8	......	−10.4	......	−12.4	......	−16.8	......	−23.3	......
San Diego, Calif. [3] (10 m)	31	5.5	−5.4	5.8	−5.6	2.7	−7.1	−0.2	−6.8	−1.6	−6.9	−2.6	−5.0	−4.7	−5.6	−9.9	−4.6	−16.1	−3.9
Sault St. Marie, Mich. [2] (221 m)	29	−9.8	......	−8.7	......	−10.6	......	−11.5	......	−11.7	......	−12.3	......	−14.1	......	−18.8	......	−24.7	......
Scott Field (Belleville), Ill. [1] (135 m)	13	−5.9	......	−3.5	......	−0.5	......	−1.2	......	−3.2	......	−4.9	......	−6.4	......	−9.5	......	−15.3	......
Seattle, Wash. [3] (10 m)	9	−0.3	......	−3.5	......	−5.7	......	−7.2	......	−9.6	......	−11.9	......	−14.9	......	−22.1	......	−30.8	......
Selfridge Field (Mount Clemens), Mich. [1] (177 m)	26	−4.0	......	−3.6	......	−3.6	......	−3.0	......	−3.7	......	−5.1	......	−6.7	......	−11.7	......	−16.9	......
Spokane, Wash. [2] (596 m)	29	−13.3	......	......	......	−11.9	......	−11.9	......	−12.0	......	−13.2	......	−15.2	......	−20.3	......	−25.9	......
Washington, D. C. [2] (13 m)	22	5.9	+6.5	5.0	+6.0	4.4	+6.3	3.4	+6.2	2.8	+6.6	1.5	+6.1	−0.8	+5.9	−5.4	+5.0	−11.4	+4.6
Wright Field (Dayton), Ohio [1] (244 m)	15	−0.4	+2.8	−1.4	+2.1	−1.1	+2.7	−1.8	+2.0	−3.3	+1.5	−4.9	+1.8	−6.8	+1.9	−10.9	+2.5	−16.5	+3.2

Observations taken about 4 a. m., 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

[1] Army.

[2] Weather Bureau.

[3] Navy.

NOTE.—The departures are based on normals covering the following total number of observations made during the same month in previous years, including the current month (years of record are given in parenthesis following the number of observations): Billings, 91 (3); Boston, 92 (5); Cheyenne, 92 (3); Fargo, 90 (3); Kelly Field, 72 (3); Mitchel Field, 56 (3); Murfreesboro, 88 (3); Oklahoma City, 82 (3); Omaha, 179 (6); Pensacola, 178 (9); San Diego, 213 (9); Scott Field, 52 (3); Washington, 175 (12); Wright Field, 60 (3).

TABLE 2.—*Mean free-air relative humidities (R. H.), in percent, and specific humidities (q), in grams/kilogram, obtained by airplanes during January 1937. (Dep. represents departure from "normal" relative humidity)*

Stations	Number of obs.	Surface			500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
		q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.	q	R. H. Mean	R. H. Dep.
Barksdale Field, La	16	6.3	84	----	5.8	73	----	4.3	50	----	4.1	52	----	3.5	44	----	3.3	46	----	2.9	44	----	1.9	36	----			
Billings, Mont	30	0.8	67	+3							0.9	63	+6	1.0	65	+9	1.0	66	+8	1.0	70	+8	0.7	60	+4	0.4	67	+1
Boston, Mass	19	2.9	71	−1	2.9	71	−2	2.7	67	−4	2.3	51	−12	1.9	44	−14	1.7	40	−15	1.6	39	−15	1.2	40	−13			
Cheyenne, Wyo	31	1.1	58	−2										1.2	57	−2	1.2	55	0	1.1	53	−1	0.8	53	+1	0.6	54	+3
El Paso, Tex	31	2.4	48	----							2.7	43	----	2.6	43	----	2.4	43	----	2.1	41	----	1.3	31	----	0.9	29	----
Fargo, N. Dak	30	0.5	71	−8	0.6	70	−6	0.8	67	−4	0.9	61	−5	0.9	53	−5	0.9	57	−2	0.8	58	0	0.7	58	+3	0.3	56	+3
Kelly Field, Tex	18	6.1	89	+5	5.9	68	+2	5.7	63	+4	5.3	57	+7	5.1	55	+10	4.3	48	+10	3.5	44	+8	2.6	47	+13	1.7	47	+15
Lakehurst, N. J	17	2.9	65	----	2.7	64	----	2.4	58	----	2.3	44	----	2.2	40	----	2.2	42	----	1.9	39	----	1.6	42	----			
Maxwell Field, Ala	14	9.3	79	----	8.4	71	----	7.2	63	----	6.3	63	----	5.0	53	----	3.6	40	----	2.7	34	----	1.4	22	----	0.9	20	----
Miami, Fla	30	13.1	85	----	12.9	82	----	10.5	82	----	8.3	70	----	6.3	55	----	5.0	46	----	3.8	38	----	2.5	32	----	1.4	26	----
Mitchel Field, N. Y	18	3.1	78	+4	3.0	76	+4	2.6	60	−5	2.1	44	−13	2.0	41	−13	1.9	39	−12	1.9	42	−9	1.3	35	−13	0.9	37	−12
Murfreesboro, Tenn	29	5.9	89	+6	5.9	86	+6	6.0	81	+6	5.0	67	+2	4.1	57	0	3.5	51	−2	3.0	46	−4	2.0	43	−2	1.3	42	−3
Norfolk, Va	5	7.3	84	----	7.4	79	----	6.3	70	----	5.2	65	----	4.2	56	----	3.0	41	----	2.9	41	----	2.4	50	----	1.9	52	----
Oakland, Calif	30	3.7	77	----	3.7	73	----	3.3	72	----	2.9	69	----	2.4	59	----	1.8	51	----	1.5	46	----	1.0	43	----	0.7	42	----
Oklahoma City, Okla	27	3.0	83	+6	3.0	79	+5	2.9	59	0	2.6	45	−4	2.1	40	−4	1.9	37	−4	1.7	33	−5	1.1	33	−4	0.7	33	−4
Omaha, Nebr	31	0.9	78	−3	0.9	74	−4	1.3	68	0	1.5	58	−1	1.4	51	−2	1.3	51	−1	1.1	48	−3	0.8	47	−2	0.4	45	−1
Pensacola, Fla	23	11.4	89	+7	10.4	82	+7	8.7	72	+3	8.2	76	+14	7.4	74	+14	5.5	56	+7	4.5	50	0	2.8	41	−2	2.0	38	0
St. Thomas, V. I	26	14.9	84	----	15.2	91	----	13.0	88	----	11.5	87	----	9.7	80	----	6.6	58	----	4.9	47	----	2.7	33	----	1.5	26	----
Salt Lake City, Utah	31	1.6	70								2.0	70	----	1.9	70	----	1.8	71	----	1.6	73	----	1.2	73	----	0.8	72	----
San Diego, Calif	31	4.5	80	+9	4.5	74	+12	3.8	74	+20	3.2	72	+20	2.8	66	+23	2.4	57	+16	2.0	52	+17	1.2	45	+11	0.6	40	+4
Sault Ste. Marie, Mich	29	1.5	84	----	1.8	86	----	1.6	83	----	1.4	74	----	1.2	64	----	1.1	55	----	1.0	53	----	0.8	55	----	0.6	56	----
Scott Field, Ill	13	2.0	76	----	2.3	68	----	2.4	54	----	2.0	46	----	1.8	47	----	1.7	46	----	1.5	43	----	1.1	36	----	0.9	34	----
Seattle, Wash	9	2.7	72	----	2.3	73	----	2.1	75	----	2.0	73	----	1.7	71	----	1.5	70	----	1.3	69	----	0.8	68	----	0.1	66	----
Selfridge Field, Mich	25	2.2	76	----	2.3	78	----	2.1	64	----	1.9	51	----	1.7	47	----	1.6	44	----	1.3	39	----	1.0	37	----	0.7	37	----
Spokane, Wash	29	1.2	78	----				1.3	77	----	1.4	77	----	1.4	73	----	1.3	72	----	1.2	72	----	0.8	68	----	0.6	66	----
Washington, D. C	22	4.2	74	+5	4.1	72	+10	4.0	68	+10	3.9	67	+13	3.4	57	+8	3.1	54	+7	2.6	51	+9	1.5	37	−1	0.9	30	−10
Wright Field, Ohio	15	3.1	84	+3	2.9	82	+3	2.6	66	−5	2.5	61	−2	2.1	56	−1	1.9	52	−4	1.5	43	−9	0.9	34	−14	0.5	32	−12

Altitude (meters) m. s. l.

TABLE 3.—*Mean free-air barometric pressures (P), in mb, and equivalent potential temperatures (Θ_e), in °A, obtained by airplanes during January 1937*

Stations	Number of observations	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000	
		P	Θ_e	P	Θ_e	P	Θ_e	P	Θ_e	P	Θ_e	P	Θ_e	P	Θ_e	P	Θ_e	P	Θ_e
Barksdale Field, La	16	1,014	299	961	302	905	304	851	307	802	309	754	312	708	314	625	316		
Billings, Mont	30	889	268					842	274	788	279	738	284	690	288	604	292	526	294
Boston, Mass	19	1,025	280	964	285	906	287	851	293	800	296	751	299	705	302	621	306		
Cheyenne, Wyo	31	803	281							790	284	740	290	694	294	607	298	530	300
El Paso, Tex	31	880	292					847	300	797	303	748	306	704	308	620	311	547	315
Fargo, N. Dak	30	986	253	956	257	895	267	838	274	785	280	735	284	688	286	600	292	523	295
Kelly Field, Tex	18	995	298	960	304	904	308	852	312	802	316	755	318	710	318	628	319	553	320
Lakehurst, N. J	17	1,025	281	968	284	909	288	854	294	803	298	754	303	709	305	624	309		
Maxwell Field, Ala	14	1,014	313	962	314	907	316	854	316	805	316	757	316	713	316	630	318	557	320
Miami, Fla	30	1,020	329	964	334	910	328	857	325	809	323	762	323	718	323	636	323	561	324
Mitchel Field, N. Y	18	1,026	280	969	285	910	289	854	293	803	297	754	301	708	305	623	309	549	311
Murfreesboro, Tenn	29	1,000	298	962	300	905	306	852	308	802	310	754	311	709	313	626	315	552	317
Norfolk, Va	5	1,020	302	962	308	905	308	851	308	802	310	753	311	708	313	624	317	550	320
Oakland, Calif	30	1,019	285	958	291	900	292	846	294	794	296	746	297	700	300	615	303	540	306
Oklahoma City, Okla	27	972	282	959	284	901	292	846	298	796	300	747	303	702	306	619	308	544	310
Omaha, Nebr	31	984	262	959	265	897	274	840	284	788	288	738	292	692	294	607	298	530	300
Pensacola, Fla	23	1,019	321	963	322	908	322	855	323	805	324	758	323	713	323	630	323	556	326
St. Thomas, V. I	26	1,016	337	960	341	906	338	854	336	805	334	758	328	714	327	632	326	558	326
Salt Lake City, Utah	31	868	277					845	284	792	288	743	292	697	294	610	299	534	302
San Diego, Calif	31	1,017	290	958	295	900	295	845	296	794	298	745	302	700	304	616	307	541	309
Sault Ste. Marie, Mich	29	993	268	958	273	898	275	840	279	787	283	736	288	690	291	603	297	527	301
Scott Field, Ill	13	1,008	272	962	279	902	287	847	291	795	294	746	297	700	300	615	307	540	311
Seattle, Wash	9	1,019	279	959	279	900	282	845	285	792	287	742	289	696	291	609	292	533	291
Selfridge Field, Mich	26	1,001	275	961	279	903	283	847	289	796	293	747	296	701	299	615	304	540	309
Spokane, Wash	29	947	267			899	273	843	278	790	284	740	288	693	291	606	294	530	299
Washington, D. C	22	1,023	289	962	293	905	297	851	301	800	304	752	307	706	309	622	312	547	315
Wright Field, Ohio	15	993	281	961	283	904	287	849	291	797	294	748	297	702	300	617	304	541	307

TABLE 4.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 5 a. m. (E. S. T.) during January 1937*

[Wind from N=360°, E=90°, etc.]

Altitude (m) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Billings, Mont. (1,088 m)		Boston, Mass. (15 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cincinnati, Ohio (153 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°	
Surface	322	1.7	358	1.0	250	2.7	284	2.0	264	4.5	237	1.6	21	0.2
500			94	1.0			305	4.6			239	4.4	197	3.3
1,000			122	1.9			292	5.8			256	9.7	238	7.9
1,500			259	6.9	248	6.3	297	10.7			260	11.8	246	9.3
2,000	260	3.9	259	9.4	284	6.1	278	11.8	261	6.5	267	15.2		
2,500	254	7.5	256	9.7	281	8.1	285	11.6	257	10.9	266	15.1		
3,000	254	11.6			285	8.5	273	12.6	258	11.6	268	16.4		
4,000	258	19.0			280	10.7			253	11.0				
5,000														

Altitude (m) m. s. l.	Detroit, Mich. (204 m)		Fargo, N. Dak. (274 m)		Houston, Tex. (21 m)		Key West, Fla. (11 m)		Medford, Oreg. (410 m)		Murfreesboro, Tenn. (180 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°	
Surface	249	1.9	301	1.7	43	1.4	98	4.2	78	0.3	243	0.9
500	245	2.5	285	2.6	83	2.6	110	10.0	224	0.2	186	4.3
1,000	261	4.4	283	5.7	328	0.6	112	8.9	195	1.6	202	8.5
1,500	263	10.8	281	7.5	245	3.4	124	6.8	258	3.0	242	7.7
2,000	266	11.6	279	8.9	249	6.0	117	6.5	263	3.2	252	8.5
2,500	267	12.7	282	12.1	239	8.8	116	5.6	324	4.3	257	12.3
3,000	256	15.6	267	13.3	242	12.0	115	2.8	346	5.4	260	14.0
4,000												
5,000												

Altitude (m) m. s. l.	Newark, N. J. (14 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Pearl Harbor, Territory of Hawaii[1] (68m)		Pensacola, Fla.[1] (24 m)		St. Louis, Mo. (170 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°	
Surface	345	2.4	95	1.5	19	0.7	307	1.2			82	1.9	312	1.8
500	6	3.4	334	1.9	129	2.2	276	2.0			153	6.3	281	2.5
1,000	314	2.1	333	3.8	197	3.9	277	6.3			193	7.7	268	3.7
1,500	276	5.6	326	5.8	231	7.8	271	9.3			201	8.0	257	8.4
2,000	260	8.9	331	7.6	230	10.2	262	12.0			204	9.1	247	10.1
2,500	269	10.8	348	10.4	232	10.4	261	12.3			206	10.0	256	11.4
3,000	270	10.4	345	16.8			252	10.3					252	15.3
4,000	283	14.2	360	17.9										
5,000														

Altitude (m) m. s. l.	Salt Lake City, Utah (1,294 m)		San Diego, Calif. (15 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Spokane, Wash. (603 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°	
Surface	163	2.3	35	0.7	209	1.0	38	0.9	61	1.3	12	1.2
500			313	1.1	216	3.5	60	1.7			338	1.8
1,000			297	2.6	233	6.5	47	0.7	97	2.6	294	4.3
1,500	171	4.0	294	3.5	258	10.2	15	1.5	95	2.2	259	7.8
2,000	197	4.3	288	5.4	267	14.0	356	2.1	353	2.6	271	8.4
2,500	224	4.3	287	8.2			9	2.3	337	2.8	255	12.9
3,000	255	6.3	292	9.6			32	2.7	311	3.2		
4,000			285	10.2								
5,000												

[1] Navy stations.

TABLE 5.—*Maximum free air wind velocities (M. P. S.) for different sections of the United States, based on pilot-balloon observations during January 1937*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station	Maximum velocity	Direction	Altitude (m) M. S. L.	Date	Station
Northeast [1]	41.5	WSW	1,320	9	Kylertown, Pa	39.0	W	2,920	12	Burlington, Vt	33.1	W	7,020	27	Albany, N. Y.
East Central [2]	43.8	SW	1,470	18	Knoxville, Tenn	45.0	WSW	3,240	3	Greensboro, N. C	31.0	WSW	5,250	25	Knoxville, Tenn.
Southeast [3]	33.2	WSW	2,500	3	Atlanta, Ga	34.4	W	2,740	3	Atlanta, Ga	24.8	SW	6,060	23	Charleston, S. C.
North Central [4]	38.0	WSW	1,730	4	Detroit, Mich	50.5	W	3,890	9	Detroit, Mich	52.8	WSW	5,330	10	Detroit, Mich.
Central [5]	39.0	WNW	1,720	31	Chicago, Ill	45.9	SW	5,000	17	Wichita, Kans	46.0	SW	5,020	17	Wichita, Kans.
South Central [6]	34.0	WSW	2,220	24	Dallas, Tex	46.2	W	4,630	2	Amarillo, Tex	44.6	WNW	6,790	15	Amarillo, Tex.
Northwest [7]	28.0	W	1,510	3	Billings, Mont	43.6	N	3,820	19	Medford, Oreg	59.0	N	8,030	7	Portland, Oreg.
West Central [8]	37.4	W	2,290	3	Cheyenne, Wyo	54.0	NNW	3,690	17	Oakland, Calif	65.0	WSW	9,960	26	Rock Springs, Wyo.
Southwest [9]	28.0	SW	2,100	1	Winslow, Ariz	50.0	SSW	3,984	7	Albuquerque, N. Mex	53.2	W	8,600	2	Winslow, Ariz.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

LATE REPORTS

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during December 1936*

TEMPERATURE (° C.)

Stations	Altitude (meters) m. s. l.																		Number of observations
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Coco Solo, Canal Zone,[3] (15 m)	24.7		22.1		19.1		16.3		14.3		12.2		9.8		5.6		0.5		28
Pearl Harbor, Territory of Hawaii[3] (6 m)	21.6	−1.4	19.4	−0.9	15.5	−1.1	12.5	−1.4	10.5	−1.5	8.8	−1.5	6.8	−1.3	0.9	−1.5			31

RELATIVE HUMIDITY (PERCENT)

Stations	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
Coco Solo, Canal Zone	88		90		87		80		70		59		52		40		20		
Pearl Harbor, Territory of Hawaii	78	+1	78	0	83	+2	78	+3	64	0	47	−4	36	−6	20	−13			

[3] Navy.

Observations taken about 4 a. m., 75th meridian time, except by Navy Stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—The departures are based on normals covering the following total number of observations made during the same month in previous years, including the current month. (Years of record are given in parenthesis following the number of observations.) Pearl Harbor, 139 (8).

LATE REPORT

TABLE 1.—*Mean free-air temperatures and relative humidities obtained by airplanes during November 1936*

TEMPERATURE (° C.)

Stations	Altitude (meters) m. s. l.																		Number of observations
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	
Coco Solo, Canal Zone[3]	25.3		23.0		20.7		18.4		16.1		13.8		12.2		7.8		2.9		25

RELATIVE HUMIDITY (PERCENT)

Stations	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000		
Coco Solo, Canal Zone	90		90		88		85		84		77		72		61		59		

[3] Navy.

RIVERS AND FLOODS

[River and Flood Division, W. J. MOXOM, temporarily in charge]

By BENNETT SWENSON

Unprecedented floods occurred during January 1937 in the Ohio River Valley. Complete reports of estimated flood losses are not yet available, but it is safe to assume that they were the largest of record. At the close of the month the Ohio River flood crest had not reached the Mississippi River at Cairo, Ill.

A report on the January 1937 floods will be made in the February issue of the REVIEW.

ESTIMATED FLOOD LOSSES DURING THE YEAR 1936

The estimated flood losses during the year 1936 are presented in the table below. The losses suffered during the disastrous floods of March and April comprise by far the greater part of the losses for the entire year.

Because of the widespread area over which the floods of March and April occurred and because of their severity, it has been possible only to obtain a very rough estimate of the losses incurred.

The loss due to suspension of business, including the wages lost to employees, was undoubtedly great during these floods but only in a few cases has it been possible even to give an approximation. Wherever such an approximation is available it has been included in the totals.

The amount of damage to land by gullying or other severe erosion or by deposit of silt, sand, gravel, rocks, or other debris, too, was of great magnitude. However, it is rather difficult to distinguish between that caused by the floods in the rivers or that caused by rainfall. Also it is not known what the effect will be of the great amount of sand which was spread over the farm land. For these reasons it was not considered advisable to include these figures with the losses.

From the data available the total losses incurred during the floods of March and April exceeded $270,000,000. This sum is slightly less than the estimates of the losses of the Mississippi River flood of 1927 which extended over a period of 6 months.

The splendid cooperation of the Bureau of Public Roads and the Extension Service of the United States Department of Agriculture in collecting information on damages

to State highways and bridges and losses to agriculture is gratefully acknowledged. Credit is also due to the United States Engineer Office, the National Emergency Council in its Report of Loss and Damage, March 1936, Flood in Pennsylvania, and the New Hampshire Flood Reconstruction Council in its Report of the 1936 Flood, for their invaluable assistance in the compilation of the losses due to the floods in the spring of 1936.

TOTAL FLOOD LOSSES FOR 1936

ST. LAWRENCE DRAINAGE—LAKE ERIE

Maumee River in Indiana

Tangible property totally or partially destroyed	$6, 500
Suspension of business, including wages of employees	2, 000
Total	8, 500

ATLANTIC SLOPE DRAINAGE

Rivers in Maine and eastern Massachusetts except the Merrimack River

Tangible property totally or partially destroyed	11, 395, 100
Livestock and other movable farm property	[1] 118, 200

Merrimack River in New Hampshire and Massachusetts

Tangible property totally or partially destroyed	9, 441, 000
Livestock and other movable farm property	[1] 47, 700

Connecticut River in New England

Tangible property totally or partially destroyed	38, 560, 000
Agricultural losses	3, 440, 000

Long Island Sound Drainage in Connecticut

Tangible property totally or partially destroyed	[2] 1, 021, 500

Hudson River in New York

Tangible property totally or partially destroyed	900, 700
Livestock and other movable farm property	[1] 35, 300

Delaware River in New York, Pennsylvania, and New Jersey

Tangible property totally or partially destroyed	5, 064, 200
Livestock and other movable farm property	[1] 77, 600

Susquehanna River in New York and Pennsylvania

Tangible property totally or partially destroyed	55, 077, 450
Prospective crops	922, 600
Matured crops	930, 700
Livestock and other movable farm property	1, 493, 400
Suspension of business, including wages of employees	6, 000, 000

Potomac River in West Virginia, Maryland, and Virginia

Tangible property totally or partially destroyed	8, 888, 500
Livestock and other movable farm property	[1] 576, 200

York and Rappahannock Rivers in Virginia

Tangible property totally or partially destroyed	166, 400
Livestock and other movable farm property	[1] 8, 100

James River in Virginia

Tangible property totally or partially destroyed	1, 672, 050
Livestock and other movable farm property	[1] 119, 750
Suspension of business, including wages of employees	78, 100

[1] Including damages to crops.
[2] Highways and bridges only.

Roanoke River in Virginia and North Carolina

Tantible property totally or partially destroyed	$71, 800
Prospective crops	39, 500
Matured crops	25, 000
Livestock and other movable farm property	62, 400
Suspension of business, including wages of employees	81, 600

Blackwater River in Virginia and North Carolina

Tangible property totally or partially destroyed	105, 100
Livestock and other movable farm property	[1] 16, 550

Tar River in North Carolina

Tangible property totally or partially destroyed	12, 800
Prospective crops	3, 500
Livestock and other movable farm property	10, 000
Suspension of business, including wages of employees	13, 500

Neuse River in North Carolina

Tangible property totally or partially destroyed	123, 700
Prospective crops	24, 000
Matured crops	2, 000
Livestock and other movable farm property	20, 000
Suspension of business, including wages of employees	33, 500

Cape Fear River in North Carolina

Tangible property totally or partially destroyed	17, 200
Prospective crops	4, 500
Livestock and other movable farm property	29, 000
Suspension of business, including wages of employees	14, 000

Yadkin-Pee Dee River in North Carolina and South Carolina

Tangible property totally or partially destroyed	86, 500
Prospective crops	85, 600
Matured crops	6, 000
Livestock and other movable farm property	15, 400
Suspension of business, including wages of employees	10, 475

Black River in South Carolina

Tangible property totally or partially destroyed	2, 000
Prospective crops	60, 000
Matured crops	10, 000
Livestock and other movable farm property	500
Suspension of business, including wages of employees	4, 000

Lynches River in South Carolina

Tangible property totally or partially destroyed	500
Prospective crops	1, 000
Matured crops	1, 000
Livestock and other movable farm property	100
Suspension of business, including wages of employees	1, 000

Waccamaw River in South Carolina

Tangible property totally or partially destroyed	2, 000
Matured crops	25, 000
Livestock and other movable farm property	6, 000
Suspension of business, including wages of employees	54, 000

Santee River in North Carolina and South Carolina

Tangible property totally or partially destroyed	396, 000
Prospective crops	196, 000
Matured crops	5, 350
Livestock and other movable farm property	4, 550
Suspension of business, including wages of employees	80, 700

Edisto River in South Carolina

Tangible property totally or partially destroyed	12, 000
Prospective crops	30, 000
Matured crops	2, 000
Suspension of business, including wages of employees	1, 000

[1] Including damages to crops.

Ogeechee and Savannah Rivers in South Carolina and Georgia

Tangible property totally or partially destroyed	$308, 850
Matured crops	22, 000
Livestock and other movable farm property	24, 000
Suspension of business, including wages of employees	40, 200

Altamaha River in Georgia

Tangible property totally or partially destroyed	63, 000
Prospective crops	46, 650
Matured crops	4, 700
Livestock and other movable farm property	16, 600
Suspension of business, including wages of employees	54, 000
Total	148, 422, 875

EAST GULF OF MEXICO DRAINAGE

Chattahoochee and Apalachicola Rivers in Georgia and Florida

Tangible property totally or partially destroyed	58, 100
Matured crops	300
Livestock and other movable farm property	360, 900
Suspension of business, including wages of employees	32, 200

Conecuh, Escambia, and Pea Rivers in Alabama

Tangible property totally or partially destroyed	28, 800
Livestock and other movable farm property	260
Suspension of business, including wages of employees	8, 650

Alabama River in Alabama

Tangible property totally or partially destroyed	354, 700
Prospective crops	70, 300
Matured crops	2, 200
Livestock and other movable farm property	7, 050
Suspension of business, including wages of employees	48, 650

Black Warrior and Tombigbee Rivers in Alabama and Mississippi

Tangible property totally or partially destroyed	8, 850
Prospective crops	650
Livestock and other movable farm property	6, 110
Suspension of business, including wages of employees	13, 800

Pascagoula River in Mississippi

Tangible property totally or partially destroyed	126, 500
Prospective crops	11, 300
Matured crops	3, 800
Livestock and other movable farm property	6, 400
Suspension of business, including wages of employees	17, 000

Pearl River in Mississippi

Tangible property totally or partially destroyed	63, 500
Prospective crops	1, 500
Matured crops	250
Livestock and other movable farm property	2, 000
Suspension of business, including wages of employees	7, 000
Total	1, 240, 770

MISSISSIPPI SYSTEM—UPPER MISSISSIPPI BASIN

Minnesota River in Minnesota

Tangible property totally or partially destroyed	25, 000
Prospective crops	10, 000

Wisconsin River in Wisconsin

Tangible property totally or partially destroyed	3, 500
Suspension of business, including wages of employees	5, 000

Illinois River in Illinois

Tangible property totally or partially destroyed	41, 300
Livestock and other movable farm property	3, 000

Upper Mississippi River

Tangible property totally or partially destroyed	$136, 900
Prospective crops	19, 000
Livestock and other movable farm property	5, 000
Suspension of business, including wages of employees	64, 700
Total	313, 400

MISSISSIPPI SYSTEM—MISSOURI BASIN

Solomon River in Kansas

Tangible property totally or partially destroyed	300
Prospective crops	1, 000

Republican River in Kansas

Prospective crops	500

Grand River in Missouri

Tangible property totally or partially destroyed	25, 500

Big Sioux River in Iowa

Tangible property totally or partially destroyed	8, 500
Matured crops	500
Livestock and other movable farm property	300
Suspension of business, including wages of employees	7, 100

Floyd River in Iowa

Tangible property totally or partially destroyed	13, 000
Matured crops	250
Suspension of business, including wages of employees	5, 450

Missouri River

Tangible property totally or partially destroyed	27, 000
Prospective crops	20, 000
Total	109, 400

MISSISSIPPI SYSTEM—OHIO BASIN

Allegheny River in Pennsylvania

Tangible property totally or partially destroyed	72, 826, 430
Livestock and other movable farm property	[1] 120, 000

Monongahela River in West Virginia and Pennsylvania

Tangible property totally or partially destroyed	34, 491, 400
Livestock and other movable farm property	[1] 62, 000

Beaver River in Pennsylvania

Tangible property totally or partially destroyed	33, 000
Livestock and other movable farm property	[1] 8, 500

Little Kanawha River in West Virginia

Tangible property totally or partially destroyed	41, 430

Green River in Kentucky

Tangible property totally or partially destroyed	13, 100
Livestock and other movable farm property	[1] 85, 000
Suspension of business, including wages of employees	6, 100

West Fork of White River in Indiana

Tangible property totally or partially destroyed	22, 500
Matured crops	2, 400
Suspension of business, including wages of employees	1, 500

East Fork of White River in Indiana

Tangible property totally or partially destroyed	2, 000
Prospective crops	1, 500
Matured crops	2, 500

White River in Indiana

Matured crops	5, 000

Wabash River in Indiana

Tangible property totally or partially destroyed	153, 600
Prospective crops	7, 000
Matured crops	103, 650
Livestock and other movable farm property	1, 740
Suspension of business, including wages of employees	3, 300

[1] Including damages to crops.

Cumberland River in Kentucky and Tennessee

Tangible property totally or partially destroyed	$1, 250
Livestock and other movable farm property	[1] 11, 850
Suspension of business, including wages of employees	12, 700

Tennessee River in Alabama and Tennessee

Tangible property totally or partially destroyed	190, 020
Livestock and other movable farm property	[1] 471, 610
Suspension of business, including wages of employees	18, 000

Ohio River

Tangible property totally or partially destroyed	12, 238, 550
Livestock and other movable farm property	[1] 312, 300
Suspension of business, including wages of employees	1, 045, 660
Total	122, 295, 590

MISSISSIPPI SYSTEM—ARKANSAS BASIN

Cimarron River in Oklahoma

Tangible property totally or partially destroyed	2, 000
Prospective crops	500
Matured crops	1, 000

Verdigris River in Oklahoma

Prospective crops	1, 000

North Canadian River in Oklahoma

Tangible property totally or partially destroyed	44, 800
Prospective crops	29, 800
Matured crops	9, 800
Livestock and other movable farm property	700
Suspension of business, including wages of employees	650

South Canadian River in Oklahoma

Tangible property totally or partially destroyed	8, 500
Prospective crops	20, 800
Matured crops	3, 950
Livestock and other movable farm property	50

Petit Jean River in Arkansas

Matured crops	300
Suspension of business, including wages of employees	1, 500

Arkansas River

Tangible property totally or partially destroyed	576, 000
Prospective crops	65, 500
Matured crops	28, 500
Livestock and other movable farm property	21, 100
Total	816, 450

MISSISSIPPI SYSTEM—RED BASIN

Sulphur River in Texas

Tangible property totally or partially destroyed	100
Prospective crops	7, 000
Matured crops	4, 000
Suspension of business, including wages of employees	5, 300
Total	16, 400

MISSISSIPPI SYSTEM—LOWER MISSISSIPPI BASIN

Lower Mississippi River

Tangible property totally or partially destroyed	26, 050
Livestock and other movable farm property	[1] 22, 200
Suspension of business, including wages of employees	6, 500
Total	54, 750
Total, Mississippi System	123, 605, 990

[1] Including damages to crops.

WEST GULF OF MEXICO DRAINAGE

Trinity River in Texas

Tangible property totally or partially destroyed	$5, 250
Prospective crops	1, 000
Matured crops	71, 650
Livestock and other movable farm property	33, 800
Suspension of business, including wages of employees	1, 200

Brazos River in Texas

Tangible property totally or partially destroyed	831, 000
Prospective crops	47, 000
Matured crops	2, 339, 000
Livestock and other movable farm property	40, 300
Suspension of business, including wages of employees	74, 700

Colorado River in Texas

Tangible property totally or partially destroyed	1, 810, 190
Prospective crops	167, 500
Matured crops	72, 500
Livestock and other movable farm property	32, 400
Suspension of business, including wages of employees	1, 000

Guadalupe River in Texas

Tangible property totally or partially destroyed	435, 500
Prospective crops	1, 312, 000
Matured crops	515, 500
Livestock and other movable farm property	201, 000
Suspension of business, including wages of employees	115, 000

Nueces River in Texas

Tangible property totally or partially destroyed	4, 000
Prospective crops	100, 000
Matured crops	150, 000
Livestock and other movable farm property	5, 000

Pecos River in New Mexico and Texas

Tangible property totally or partially destroyed	10, 000
Total	8, 376, 490

PACIFIC SLOPE DRAINAGE—SAN JOAQUIN BASIN

San Joaquin River in California

Tangible property totally or partially destroyed	50, 000
Prospective crops	115, 000
Matured crops	45, 000
Livestock and other movable farm property	1, 000
Total	211, 000

SACRAMENTO BASIN

Sacramento River in California

Tangible property totally or partially destroyed	103, 000
Prospective crops	349, 850
Matured crops	153, 500
Livestock and other movable farm property	2, 200
Suspension of business, including wages of employees	38, 700
Total	647, 250

COLUMBIA BASIN

Columbia River in Oregon

Tangible property totally or partially destroyed	22, 500
Prospective crops	9, 000
Livestock and other movable farm property	760
Suspension of business, including wages of employees	1, 100
Total	33, 360
Total, Pacific slope drainage	891, 610
Total estimated losses for the United States	282, 546, 235

[1] Including damages to crops.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. Tannehill, in charge]

By H. C. HUNTER

NORTH ATLANTIC OCEAN, JANUARY 1937

Atmospheric pressure.—Pressure averaged above normal from the vicinity of southern Greenland southward and southwestward to the region of the Bahamas and the northeastern Caribbean. The Gulf of Mexico averaged slightly below normal, and the eastern half of the North Atlantic was mainly below normal; the deficiency was greater than one-third of an inch at Reykjavik, Iceland, and Valencia, Ireland. The Icelandic LOW was strongly developed from the 8th to the 23d, but the final 5 days of January were marked by moderately high pressure over Iceland. At Valencia pressure was almost continuously below 29.40 inches during the latter half of the month, and at Horta, in the Azores, from the 20th to the 31st the pressure was daily at least a quarter of an inch lower than normal, the center of the North Atlantic HIGH then being much farther west than usual.

The extreme pressure readings found in available January vessel reports are 30.80 and 27.99 inches. The higher reading was noted on the American S. S. *R. G. Stewart*, not far from Nantucket, early in the morning of the 28th. The Nantucket station, it is shown in table 1, noted a slightly higher reading that day. The lower reading was made on the liner *American Banker*, about 2 p. m. of the 23d, near 48° N. 21° W.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, January 1937*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.54	+0.11	30.02	31	28.32	23
Reykjavik, Iceland	29.07	−.39	30.00	29	28.26	21
Lerwick, Shetland Island	29.64	−.06	30.27	7	29.15	4
Valencia, Ireland	29.54	−.36	30.36	3	28.56	24
Lisbon, Portugal	30.09	−.06	30.59	5	29.04	27
Madeira	30.15	+.05	30.56	5	29.56	27
Horta, Azores	30.06	−.10	30.68	5	29.30	29
Belle Isle, Newfoundland	29.83	+.09	30.40	14	29.16	4
Halifax, Nova Scotia	30.23	+.25	30.80	28	29.56	25
Nantucket	30.24	+.20	30.83	28	29.67	3
Hatteras	30.22	+.08	30.57	6	29.80	29
Bermuda	30.31	+.15	30.50	9, 14	29.56	30
Turks Island	30.08	+.03	30.16	20	30.01	2
Key West	30.08	−.02	30.24	10	29.97	22
New Orleans	30.08	−.05	30.33	29	29.82	17

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—The month as a whole was marked by about the average number of gale reports for January, but the first week was comparatively free from notable storms, just as the final days of December had been. Several vessels which left the English Channel or its vicinity between the 20th and 31st of December on voyages to the West Indies or the Gulf of Mexico furnished reports showing no wind force greater than 6 encountered on their trips, or in one instance greater than 5; such easy passages are not frequent during the midwinter period.

About the 9th to 12th, according to pressure charts, a deep LOW of large area occupied the northeastern Atlantic, with a noteworthy extension to the southward. During its prevalence, intense gales were met by many vessels traversing the chief steamship lanes between 35° and 15° west longitude; four instances of force 12 were reported.

The marked intrusion of a large LOW into latitudes near and south of 50°, during the latter part of the month, brought high winds even to the latitude of the Azores for many days. Three instances of force 12 wind are noted as occurring during the final 9 days of January, all to eastward of longitude 35°. The master of the American liner *Excambion* reported that after passing Gibraltar on the 24th, bound for Boston, severe gales and high seas were faced for an entire week, with some damage to windows and superstructure.

One important storm traversed the western North Atlantic during this time; it developed not far to the eastward of Jacksonville early on the 28th and advanced northeastward to near Hatteras, with considerable increase in force, and further increase as it moved eastward, passing not far from Bermuda on the 30th, and then continuing to join the LOW in the eastern Atlantic. Charts IX and X indicate conditions on the 28th and 29th, respectively.

Strong trades and northers.—About the 9th and 10th, in connection with comparatively high pressure near Bermuda, intensified trades were noted northeast of the Virgin Islands. The British S. S. *Jamaica Merchant* reported a norther of considerable strength at Veracruz on the 23d.

Fog.—In January 1937 as during the month immediately preceding, fog was of decidedly rare occurrence along the central and eastern portions of the chief steamship lanes between the United States and northwestern European ports; indeed, no reports whatever during either month indicate fog between the 40th and 15th meridians. In the vicinity of the Grand Banks very little fog was met during January, mostly about the 5th, 15th, and 19th.

On the other hand, fog was unusually frequent from the vicinity of Nova Scotia southwestward to Hatteras. The square 35° to 40° north latitude, 70° to 75° west longitude had fog on 19 January days, all before the 26th. A considerable search has failed to reveal any other instance of a 5° square in the North Atlantic south of the 40th parallel having in any 1 month records of fog on as many as 19 days.

The waters near and for moderate distances off the coast from Hatteras to the mouth of the Mississippi River experienced very little fog, which is the normal situation. In the west Gulf, however, fog was of frequent occurrence, the square 25° to 30° N., 90° to 95° W., having 11 days with fog, which is an extraordinarily large number for Gulf of Mexico waters. Fog was noted on the 18th near Veracruz, where it is decidedly uncommon.

OCEAN GALES AND STORMS, JANUARY 1937

Vessel	Voyage From—	Voyage To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began January	Time of lowest barometer, January	Gale ended January	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Allan Jackson, Am. S. S.	Bucksport	Aransas Pass	35 50 N.	72 00 W.	3	11p, 3	4	29.93	SSW	SSW, 9	SSW	SSW, 9	SSW-W.
Boston City, Br. S. S.	Halifax	Cardiff	45 03 N.	58 34 W.	3	8a, 4	4	29.62	E	S, 7	SSW	ESE, 9	ESE-SW.
Tennessee, Dan. S. S.	Bamble	Newport News	58 37 N.	17 00 W.	6	11a, 6	7	29.30	WNW	W, 7	WNW	WNW, 10	W-WNW.
Black Hawk, Am. S. S.	Rotterdam	New York	48 29 N.	36 05 W.	7	5a, 7	8	29.17	S	SW, 7	WNW	NNW, 9	S-W.
American Banker, Am. S. S.	London	do	48 28 N.	39 10 W.	8	Mdt, 8	9	29.12	SW	WNW, 8	WNW	S, 9	S-NW.
Sundance, Am. S. S.	Savannah	London	46 47 N.	33 36 W.	6	4a, 9	9	29.35	WNW	SSW, 10	W	SSW, 10	SSW-W.
Pukkastan, Br. S. S.	Buenos Aires	New York	19 40 N.	50 30 W.	9	6a, 9	10	30.16	NE	NE, 8	E	NE, 8	NE-E.
Boston City, Br. S. S.	Halifax	Cardiff	[1]49 37 N.	33 03 W.	7	7a, 9	10	28.98	NW	S, 11	W	S, 11	S-W.
Tennessee, Dan. S. S.	Bamble	Newport News	57 01 N.	27 34 W.	9	1p, 9	9	28.83	SW	S, 10	WNW	S, 12	SW-S-W.
Emile Francqui, Belg. S. S.	New York	Antwerp	47 30 N.	33 00 W.	10	3p, 10	10	28.79	SW	SW	W	SW, 10	SW-W.
Tennessee, Dan. S. S.	Bamble	Newport News	56 07 N.	31 00 W.	10	11p, 10	11	28.49	SE	NE, 11	WNW	N, 12	SE-N.
Alexandre Andre, Belg. M. S.	Manchester	Baton Rouge	[1]43 03 N.	24 19 W.	11	2a, 11	12	29.56	SW	SW, 9	W	SW, 11	SW-W.
Sundance, Am S. S.	Savannah	London	48 58 N.	22 05 W.	10	3a, 11	11	29.08	SW	S, 10	WSW	S, 10	S-W.
Blankaholm, Swed. M. S.	Kotka	New York	55 52 N.	31 51 W.	7	4a, 11	15	28.22	SE	NW, 9	SW	NW, 12	S-NNW.
Independence Hall, Am. S. S.	Chester	Havre	[1]49 08 N.	23 02 W.	10	6a, 11	10	29.02	S	WSW, 7	WSW	SSW, 10	SSW-WSW.
Boston City, Br. S. S.	Halifax	Cardiff	52 10 N.	21 58 W.	10	10a, 11	11	28.93	S	WSW, 7	WSW	SSW, 12	SSW-WSW.
Caledonia, Br. S. S.	Glasgow	Boston	50 28 N.	38 58 W.	13	11p, 13	14	29.44	SW	WSW, 7	WNW	W, 10	SW-W.
Matina, Br. S. S.	Port Antonio	Liverpool	46 01 N.	34 50 W.	13	2p, 14	14	29.83	SW	NW, 11	WNW	NW, 11	SW-NW.
Black Gull, Am. S. S.	Antwerp	New York	49 40 N.	22 38 W.	13	8p, 14	14	29.36	SW	WSW, 7	W	SW, 9	WSW-W.
Sagaporack, Am. S. S.	Copenhagen	Baltimore	56 42 N.	29 10 W.	13	2p, 15	16	28.77	WSW	W, 9	WSW	W, 10	SSW-W.
Black Gull, Am. S. S.	Antwerp	New York	[1]48 22 N.	29 32 W.	16	2p, 16	19	29.12	W	W	WNW	WNW, 10	SW-WNW.
Sagaporack, Am. S. S.	Copenhagen	Baltimore	53 53 N.	38 20 W.	17	Noon, 17	18	29.13	WNW	WNW, 7	W	WNW, 10	W-WNW.
Belgian Gulf, Belg. M. S.	Port Arthur	Antwerp	49 30 N.	11 00 W.	18	4a, 18	18	29.01	WSW	WSW, 9	W	W, 10	WSW-W.
Europa, Ger. S. S.	Cherbourg	New York	46 27 N.	37 38 W.	18	9a, 19	19	[2]29.43	WNW	W	WNW	W, 11	SW-W.
Henri Jaspar, Belg. S. S.	Antwerp	do	50 25 N.	31 00 W.	18	7p, 19	22	28.66	NW	NW, 9	W	NW, 10	S-W-N.
Fort Royal, Fr. M. S.	Guadeloupe	Rouen	44 56 N.	16 58 W.	19	6a, 20	20	29.06	WSW	SW, 10	W	WSW, 12	
American Shipper, Am. S. S.	Plymouth	New York	54 32 N.	15 40 W.	19	4p, 20	21	28.16	SW	SW, 9	WSW	SW, 10	SSW-WSW.
Sagaporack, Am. S. S.	Copenhagen	Baltimore	50 50 N.	42 25 W.	19	8p, 20	22	28.92	NNW	W, 7	SSW	NW, 11	
Beemsterdijk, Du. S. S.	Rotterdam	New York	50 10 N.	27 34 W.	23	4a, 23	24	28.49	NE	NNE, 9	NW	NNE, 9	E-N-NW.
American Shipper, Am. S. S.	Plymouth	do	[1]51 50 N.	30 41 W.	22	5a, 23	25	28.86	WNW	NNW, 5	WNW	WNW, 11	W-NNW.
Silvercedar, Br. M. S.	Gibraltar	Halifax	38 48 N.	55 46 W.	23	1p, 23	23	29.77	WSW	W, 9	WNW	W, 9	WSW-WNW.
Yaka, Am. S. S.	Mobile	Havre	49 09 N.	18 30 W.	22	4p, 23	24	[2]28.02	WNW	S, 11	SW	S, 11	SSE-SSW.
West Cobalt, Am. S. S.	Houston	do	[1]48 23 N.	9 26 W.	23	4a, 24	23	28.75	S	SSW, 5	S	SE, 10	S-W.
Columbus, Ger. S. S.	Bremerhaven	New York	49 44 N.	17 20 W.	23	8a, 24	25	28.18	S	WSW, 11	N	W, 12	
Ariadne, Du. S. S.	Puerto Barrios	Amsterdam	43 40 N.	24 30 W.	21	10a, 25	26	28.98	SW	NW, 9	NW	NW, 11	
Sunetta, Du. M. S.	Curacao	Hamburg	43 30 N.	24 40 W.	21	Noon, 25	25	29.14	NW	WNW, 8	WNW	WNW, 11	None.
Breda, Du. S. S.	do	Liverpool	44 40 N.	26 03 W.	24	5p, 26	27	28.52	NW	N, 9	NNW	WNW, 12	S-NW-N.
Colombia, Du. M. S.	Dover	Barbados	39 30 N.	20 30 W.	26	Mdt, 26	27	28.75	WNW	WNW, 12	NW	WNW, 12	S-WNW.
Solana, Am. S. S.	Houston	New York	34 30 N.	75 51 W.	27	8a, 29	31	29.87	NE	NW, 10	E	NW, 10	S-NW.
Katendrecht, Du. M. S.	do	Flushing	[1]40 26 N.	37 52 W.	27	5a, 30	30	29.44	WNW	NW, 9	NNW	NW, 11	None.
Cuba, Fr. S. S.	Southampton	Guadeloupe	31 00 N.	39 15 W.	31	11p, 31	[3]1	29.47	W	SW, 10	NW	SW, 11	SSW-WNW.
NORTH PACIFIC OCEAN													
Hiye Maru, Jap. M. S.	Yokohama	Vancouver	47 30 N.	167 46 E.	1	4p, 3	1	[2]28.93	S		W	W, 8	W-WSW.
Amagisan Maru, Jap. M. S.	do	Los Angeles	41 05 N.	166 02 E.	1	3p, 2	2	[2]29.13	S	S, 10	SW	S, 10	S-SW.
Washington, Am. S. S.	Vladivostok	San Francisco	42 30 N.	178 00 E.	2	4p, 2	2	29.43	SSE	NNW, 4	S	SE, 11	SE-W-NNW.
Fernlane, Nor. M. S.	Los Angeles	Yokohama	33 06 N.	163 45 E.	2	Mdt, 2	3	29.73	S	SW, 9	WNW	SW, 9	S-WNW.
Tai Ping, Nor. M. S.	Yokohama	Los Angeles	36 54 N.	147 48 E.	2	10p, 1	3	29.67	W	W, 5	WNW	WNW, 9	None.
Golden Sun, Am. S. S.	do	San Francisco	43 18 N.	161 18 W.	3	1p, 3	3	29.94	SE	SE, 8	SE	SE, 8	
Empress of Asia, Br. S. S.	do	Victoria	48 18 N.	176 12 E.	2	Mdt, 4	3	29.16	WNW	WSW, 7	WNW	WNW, 10	W-SSW.
Heian Maru, Jap. M. S.	Vancouver	Yokohama	49 22 N.	169 57 E.	3	10a, 4	4	29.04	SE	W, 7	WSW	ESE, 9	SW-W.
Koyo Maru, Jap. S. S.	Yokohama	Port San Luis	38 19 N.	172 40 W.	5	2p, 5	6	29.63	NNE	NE, 7	NW	NW, 8	ENE-N.
Meigs, U. S. A. T.	Manila	San Francisco	[1]34 41 N.	144 11 W.	5	8a, 5	6	30.18	ENE	NE, 6	E	E, 8	None.
Golden Dragon, Am. S. S.	Cebu, P. I.	Portland, Oreg.	45 49 N.	157 55 W.	5	2p, 6	6	30.17	SE	SSE, 8	SSE	SE, 8	
Washington, Am. S. S.	Vladivostok	San Francisco	42 30 N.	168 30 W.	5	1a, 6	8	29.63	NE	NNE, 8	E	N, 11	NNE-NNW.
Fernlane, Nor. M. S.	Los Angeles	Yokohama	33 18 N.	146 08 E.	7	Noon, 7	7	29.52	SW	W, 10	NNE	W, 10	W-N.
Silverbelle, Br. M. S.	Dahikan	Los Angeles	[1]34 48 N.	155 00 E.	7	10p, 7	8	29.68	SSW	NW, —	NW	NW, 9	SSW-NW.
Washington, Am. S. S.	Vladivostok	San Francisco	41 48 N.	158 24 W.	9	1p, 9	9	30.34	E	E, 8	E	E, 8	None.
Fernwood, Nor. M. S.	Los Angeles	Kobe	30 05 N.	141 45 E.	10	8a, 10	10	[2]29.65	S	S, 6	WNW	SW, 8	S-WNW.
Winamac, Br. S. S.	Yokohama	Los Angeles	37 36 N.	152 42 E.	10	10p, 10	11	29.09	SE	S, 8	NW	W, 10	SE-WSW.
Steel Voyager, Am. S. S.	Mahukona	Balboa	20 30 N.	145 54 W.	12	2p, 11	13	29.86	ENE	E, 5	NE	NE, 8	
Do	do	do	19 42 N.	134 00 W.	14	3p, 15	17	29.90	NE	E, 6	ENE	ENE, 8	
Silverbelle, Br. M. S.	Dahikan	Los Angeles	35 15 N.	124 49 W.	20	6p, 20	21	29.96	NNW	N, 7	N	NNW, 8	
Athelcrown, Br. M. S.	Osaka	San Francisco	39 07 N.	175 34 E.	29	8a, 29	29	29.11	WSW	SE, 5	W	WSW, 9	SE-WSW.
Hokuroku Maru, Jap. M. S.	Yokohama	Los Angeles	[1]37 47 N.	146 14 E.	29	Mdt, 29	31	29.51	E	SE, 10	ENE	N, 11	SE-N.
Do	do	do	[1]43 00 N.	160 50 E.	31	8a, 1[3]	[3]1	29.44	SE	SE, 11	W	W, 11	SE-W.

[1] Position approximate. [2] Barometer uncorrected. [3] February.

NORTH PACIFIC OCEAN, JANUARY 1937

By Willis E. Hurd

Atmospheric pressure.—The pressure distribution over the entire northeastern part of the North Pacific for January 1937 was remarkably abnormal. The anticyclone over eastern waters was highly developed and persisted throughout the month, with average center, about 30.50 inches, near 45° N., 145°-150° W. The HIGH covered the eastern Aleutians and southern Alaskan waters, with few intermissions, with the consequence that the average pressures from St. Paul and Dutch Harbor to Juneau were from a third to two-thirds inch above the normal. The most remarkable departure of pressure from normal over the northern ocean was +0.65 inch at Kodiak, where the average barometric pressure for the month was 30.24. At Dutch Harbor the average pressure of 30.15, was the highest of record since 1916.

The Aleutian LOW this month lay between the western Aleutians and the eastern Kuril Islands. In this region

the lowest reported ship reading was 28.93 (uncorrected), made on the Japanese motorship *Hiye Maru*, January 1, in 47°30′ N., 167°46′ E.

On southern waters of the ocean, departures of pressure from the normal were small, but generally negative, Midway Island showing the greatest difference from normal, −0.08 inch.

A feature of unusual interest is the pronounced reversal from normal pressure conditions, as affecting a winter month, between Midway Island, in the usual January high pressure belt, and Dutch Harbor, in or near the position of the usually strongly intrenched Aleutian LOW. The pressure at Dutch Harbor was 0.20 inch higher than that at Midway Island, which is extraordinarily anomalous for January.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, January 1937, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	29.96	−0.12	30.86	31	29.06	1
Dutch Harbor	30.15	+.57	30.84	29	29.50	1
St. Paul	30.02	+.39	30.84	29	29.26	20
Kodiak	30.24	+.65	30.70	29	29.68	2
Juneau	30.22	+.34	30.83	4	29.57	24
Tatoosh Island	30.04	+.06	30.54	6	29.44	13
San Francisco	30.08	−.03	30.40	2	29.71	5
Mazatlan	29.92	−.03	30.02	25	29.84	13, 21, 22
Honolulu	29.94	−.06	30.08	15	29.70	30
Midway Island	29.95	−.08	30.14	6	29.64	18
Guam	29.88	−.02	29.94	{26, 27, 29, 30}	29.77	1, 9
Manila	29.87	−.02	29.94	25	29.74	2, 3
Hong Kong	30.05	−.06	30.28	11	29.84	31
Naha [1]						
Chichishima [1]						
Urakawa	29.99	+.06	30.30	31	29.53	5

[1] Missing.

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Cyclones and gales.—The eastern third of the ocean was practically free of cyclonic storms during January. Even as far north as Kodiak the lowest pressure, which occurred on the 2d, was 29.68, thus indicating weak cyclonic activity in northeastern waters. From 160° west longitude eastward to the American coast few ships encountered gales, and such as were met did not exceed eight in force. These were reported on 5 days: On the 6th, scattered over middle and higher latitudes; on the 9th near 42° N., 158½° W.; on the 20th, about 100 miles southwest of San Francisco; and on the 12th and 16th as intensified trades experienced by the steamer *Steel Voyager* along the twentieth parallel far to the eastward of the Hawaiian Islands.

From midocean westward cyclonic activity, while more vigorous than to the eastward, was less than is normal for January. On 4 days, however, gales of force 11, accompanied by only moderately low pressures, were experienced in scattered localities: On the 2d by the American steamer *Washington*, in 42½° N., 178° E.; on the 6th by the same steamer, in 42½° N., 168° W.; and on the 30th and 31st by the Japanese motorship *Hokuroku Maru* 2 and 3 days out from Yokohama on a voyage toward Los Angeles. This last-named ship, it may be added, encountered a force-10 gale on the 29th. The last 3 days of January, for the locality east of Honshu, provided the stormiest weather for any part of the ocean during the entire month. With the exception of the locally high winds of these dates, and an isolated gale of force 9 near 39° N., 175½° E., on the 29th, the latter half of the month was practically galeless over all parts of the ocean. The period of most frequent and widespread, and for the greater part moderate, storminess was that of the 1st to 7th, mostly confined to the western half of the sailing routes.

No tropical depressions of consequence were reported.

Fog.—Scattered fog was observed on 10 days within the region 35° to 45° N., 180° to 140° W., and on only 1 day outside it.

TYPHOON AND DEPRESSIONS OVER THE FAR EAST, DECEMBER 1936

Rev. BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

One typhoon and two depressions were reported this month. Of these, the typhoon was by far the most important disturbance; the depressions were mild and apparently of little importance.

Typhoon, November 28 to December 5.—From November 28 to December 1 a low-pressure area over the western Caroline Islands developed into a depression which moved west-northwest and then west. On December 1 it was about 400 miles east of San Bernardino Strait and, as it moved in a westerly direction toward the Philippines, it intensified into a typhoon. Its movement was quite rapid, so much so that evening observations (Dec. 1) from stations around San Bernardino Strait indicated that the locality was in danger. On December 2, 6 a. m., the center was about 60 miles east by south of Virac, Catanduanes Island, and moving west. During the day it passed close to and north of Legaspi, Albay Province. It continued this westerly course to Bondoc Peninsula, where it began to incline west-northwest, thus threatening the city of Manila. It proceeded along this course into the China Sea; the late afternoon and night hours of December 2 were anxious ones in Manila. The center passed close to and south of Manila about 7 a. m., December 3, fortunately very much weaker. The next day (Dec. 4) found it in the China Sea, still moving west-northwest, very weak, and on December 5 no traces of the storm could be found.

The following barometric minima were reported along the course of the typhoon: Virac, Catanduanes Island, on December 2, 8:40 a. m., had 738.00 mm (29.055 inches), with east winds of force 10. Legaspi, Albay Province, recorded 738.45 mm (29.073 inches), with southwest winds of force 9 at 10:45 a. m. Naga, Camarines Sur, experienced a relative calm, 2 to 3:15 p. m. of the same day. Afterward south winds, force 10, blew over the city. The absolute minimum occurred at 2 p. m., a value of 729.81 mm (28.665 inches) with north-northeast winds, force 10, which ceased at that moment. Atimonan, Tayabas Province, was affected after the typhoon inclined to the west-northwest. At 11 p. m., December 2, a relative calm was experienced, which lasted until 1 a. m., December 3. There was no rain, it was reported; however, no stars were visible. Southeast winds, forces 2 and 3, were blowing during this period. The absolute minimum was recorded at 10:15 p. m., 45 minutes before the calm area reached the city. The value observed was 742.07 mm (29.240 inches) and the winds were northeast and force 7 at the time. At Manila, 5:55 a. m., the absolute minimum was recorded, namely, 748.30 mm (29.461 inches), while northwest winds, force 6, were blowing. Throughout the early morning hours northwesterly winds prevailed, forces 5 and 6; the maximum velocity observed was 38 m. p. h. (The above pressure values have been corrected for gravity.)

The destruction due to this typhoon must be considered under two divisions: That due to the typhoon center as it passed over southern Luzon, from San Bernardino Strait to the China Sea, and that due to the heavy rains over Isabela Province. The ruin from the latter was very extensive. On December 2 and 3, as the typhoon moved across the Archipelago toward the China Sea three iives were lost together with considerable damage to houses of light material and to crops. On December 3, however, there were heavy rains over the headwaters of the Cagayan River due to the front between the southeasterly winds of the typhoon and the northeast monsoon air. The result was a terrible flood along the Cagayan River valley; the damage was greatest in Isabela Province. The provincial governor reported that one family was carried on a raft from their town in Isabela Province to a point about three miles from the mouth of the river because there was no chance to rescue them along the course of the river. The rich tobacco land along the banks of the river has been almost useless because of the thick deposit of gravel and sand left by the waters. The people suffered greatly; towns and cities along the banks were washed away suddenly by the rapid onrush of the flood. On December 18, after the government officials had visited the region and made their reports, a report of 67 dead and 173 missing was made to the public. The rainfall reports received from Echague, Isabela Province, during the period of the flood, are as follows: for the 24-hour periods ending at 6 a. m. December 3, 1.23 inches; 6 a. m. December 4, 6.81 inches; and 6 a. m. December 5, 1.68 inches. These are the only data available at present concerning the intensity of the rainfall, which caused these destructive floods so far from the path of the center of the typhoon.

Depression, December 16 to 24.—From December 16, 2 p. m., until the 18th, there existed a low-pressure area over the Western Caroline Islands, having only a vague center which moved toward the Philippines. On the morning of the 19th, there seemed to be a depression about 300 miles east of Mindanao. From the data available at the time, it was apparently moving west-northwest toward Surigao Strait. Later on, however, it was located south of Mindanao, so that its course on December 19 and 20 was west-southwest. It continued west-southwest across southern Mindanao, crossed the Moro Gulf inclining westward, passed over the northern part of the Sulu Archipelago during the afternoon of December 21, moving west by north, and entered the China Sea through the Balabac Strait. Not until December 24 could one be sure that it had filled up. At no portion of its course did it appear to have any great intensity.

Depression, December 21 to 26.—A low-pressure area over the western Caroline Islands, December 21 to 23, finally manifested itself as a depression central about 180 miles west by north of Palau Island. From this position it moved northwest to the island of Samar and was located between Borongan and Calbayog at 6 a. m. December 24. It changed its course to the west and crossed the Visayan Islands during the forenoon and afternoon. The next day, it was in the China Sea and was becoming weaker; on December 26 it was reported to be filling up. At no time were there any strong winds at the surface; and the lowest barometer reading reported was 752.1 mm (29.610 inches) from Calbayog, Samar, on December 24 at 6 a. m. Even though the winds were not strong and the barometers were quite high, there was rainfall over a large area around the center of the depression.

CLIMATOLOGICAL TABLES

DESCRIPTION OF TABLES AND CHARTS

(J. P. Kohler)

Table 1 presents average and extreme values for 45 climatic districts, based on all available data ascertained by regular and cooperative Weather Bureau stations.

Table 2 gives the data ordinarily needed for climatological studies for about 180 Weather Bureau stations making simultaneous observations at 7:30 a. m. and 7:30 p. m. daily, seventy-fifth meridian time, and for about 20 others making only one observation. The altitudes of the instruments above ground are also given.

Beginning with January 1, 1932, all wind movements and velocities published herein are corrected to true values by applying to the anemometer readings corrections determined by actual tests in wind tunnels and elsewhere.

Table 3 gives, for about 37 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation, depth of snowfall, and the respective departures from normal values except in the case of snowfall. The sea-level pressures have been computed according to the method described by Prof. F. H. Bigelow in the REVIEW of January 1902, **30:** 13–16.

Table 4 lists the severe local storms reported in the United States during the month. It is compiled from reports furnished mostly by officials of the Weather Bureau.

CHART I.—*Temperature departures.*—This chart presents the departures of the monthly mean surface temperatures from the monthly normals. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly surface temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July 1909, but smaller charts appear in W. B. Bulletin U for 1873 to June 1909, inclusive.

CHART II.—*Tracks of centers of* ANTICYCLONES; and

CHART III.—*Tracks of centers of* CYCLONES. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month, the location indicated being that at 7:30 a. m., seventy-fifth meridian time. Within each circle is also an entry of the last three figures of the highest barometric reading (chart II) or (chart III) the lowest reading reported at or near the center at that time, in both cases as reduced to sea level and standard gravity. The intermediate 7:30 p. m. locations are indicated by dots. The inset map on chart II shows the departure of monthly mean pressure from normal and the inset on chart III shows the change in mean pressure from the preceding month.

The use of a new base map for charts II and III began with the January 1930 issue.

CHART IV.—*Percentage of clear sky between sunrise and sunset.*—The average cloudiness at each regular Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the night hours.

CHART V.—*Total precipitation.*—The scales of shading with appropriate lines show the distribution of the monthly precipitation according to reports from both regular and cooperative observers. The inset on this chart shows the departure of the monthly totals from the corresponding normals, as indicated by the reports from the regular stations.

CHART VI.—*Isobars at sea level and isotherms at surface; prevailing winds.*—The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow in the REVIEW for January 1902, **30**: 13–16. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of 7:30 a. m. and 7:30 p. m. readings at stations taking two observations daily, and to the 7:30 a. m. or the 7:30 p. m. observation at stations taking but a single observation.

The diurnal corrections so applied, except for stations established since 1901, will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, table 27, pages 140–164.

The sea-level temperatures are now omitted and average surface temperatures substituted. The isotherms cannot be drawn in such detail as might be desired, for data from only the regular Weather Bureau stations are used.

The prevailing wind directions are determined from hourly observations at almost all the stations. A few stations determine their prevailing directions from the daily or twice-daily observations only.

CHART VII.—*Wind roses for selected stations.*—The publication of this chart began in the REVIEW for January 1935 and gives wind roses for 28 selected stations. The roses are based on hourly percentages for the month.

CHART VIII.—*Total snowfall.*—This is based on the reports from regular and cooperative observers and shows the depth in inches of the snowfall during the month. In general the depth is shown by lines connecting places of equal snowfall, but in special cases figures also are given. This chart is published only when the snowfall is sufficiently extensive to justify its preparation. The inset on this chart, when included, shows the depth of snow on the ground at 7:30 p. m. of the Monday nearest the end of the month and is a copy of the snow chart appearing in the snow and ice bulletin for that week.

CHARTS IX, X, ETC.—*North Atlantic weather maps for particular days.*

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, January 1937*

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	58.7	+12.3	Evergreen	86	18	Florence	22	4	8.54	+3.70	Cordova	15.35	Geneva	2.63
Arizona	32.9	−10.7	Granite Reef	82	7	Fort Valley	−31	22	1.73	+.47	Fort Valley	4.63	2 stations	.10
Arkansas	41.8	+.5	Portland	80	8	3 stations	9	[1] 22	12.61	+8.22	Big Lake Outlet	21.26	Fort Smith	4.41
California	34.4	−10.2	Yorba Linda	71	10	Boca	−45	20	3.92	−.89	Upper Mattole	14.66	El Centro	.03
Colorado	13.9	−10.0	Walsenburg	78	12	Sunbeam (near)	−47	[1] 9	.77	+.01	Pagosa Springs (near)	12.95	Haswell	T
Florida	69.3	+10.1	Daytona Beach	92	15	Quincy	39	28	1.78	−1.01	Jacksonville	4.52	Clermont	.00
Georgia	58.1	+11.0	Fargo	87	10	Dahlonega	26	4	6.85	+2.53	Clayton	13.89	Waycross	1.35
Idaho	8.8	−15.0	Bungalow	56	16	Tetonia	−48	21	1.83	−.37	Roland	4.88	Challis	.06
Illinois	28.3	+1.8	Cairo	67	14	Henry	−12	23	5.98	+3.64	Brookport	19.03	La Salle	2.01
Indiana	33.4	+4.3	Seymour	75	9	Albion	−13	[1] 23	9.91	+6.74	Evans Landing	21.39	Whiting	1.92
Iowa	12.8	−5.6	Keokuk	46	6	2 stations	−30	[1] 10	2.25	−1.15	Melrose	4.79	Lenox	.48
Kansas	21.3	−8.3	Johnson	63	16	Bun Oak	−20	23	1.40	+.73	Pittsburg	5.33	2 stations	T
Kentucky	43.6	+7.6	Pippapass	76	8	Lovelaceville	13	23	15.75	+11.18	Earlington	22.97	Pikeville	8.39
Louisiana	59.1	+7.3	3 stations	85	[1] 10	Ruston	25	23	8.72	+3.79	Melville	18.87	Port Eads	1.44
Maryland-Delaware	41.9	+7.9	Takoma, Md	77	9	2 stations	11	5	7.52	+4.22	Millsboro, Del	11.46	Keedysville, Md	4.63
Michigan	23.7	+2.7	St. Joseph	63	8	Bessemer	−27	26	2.32	+.48	Painesdale	6.21	St. Ignace	.60
Minnesota	−.8	−10.0	Winona	42	4	Pokegama Falls	−47	19	1.45	+.69	Pigeon River Bridge	3.51	Hastings	.44
Mississippi	55.7	+8.2	Forest	88	22	Tunica	21	23	11.43	+6.26	Hickory	21.48	Biloxi	1.79
Missouri	28.5	−2.3	Caruthersville	70	14	Louisiana	−15	23	6.38	+3.99	Parma	16.61	2 stations	2.16
Montana	−.4	−19.7	Simpson (near)	48	4	Seeley Lake	−53	7	.77	−.11	Hebgen Dam	3.44	Mildred	.05
Nebraska	9.9	−13.0	2 stations	49	4	Gordon	−27	7	.89	+.37	Tecumseh	2.27	Kowanda	T
Nevada	13.5	−15.8	Las Vegas	61	31	San Jacinto	−50	8	1.46	+.27	Marlette Lake	6.34	Thorne	.23
New England	30.8	+8.1	Fitchburg, Mass	68	25	Fort Kent, Maine	−26	28	4.36	+.85	Old Greenwich, Conn.	8.19	Burlington, Vt	1.63
New Jersey	40.3	+9.4	Hammonton	72	9	Dayton	9	28	6.30	+2.73	Indian Mills	8.31	Sandy Hook	4.61
New Mexico	26.5	−7.1	Hatch	77	28	Gavilan (near)	−37	22	.38	−.18	Bateman's ranch	2.26	8 stations	.00
New York	31.5	+8.2	Cairo	68	15	North Lake	−16	27	4.86	+1.89	High Market	8.51	Avon	1.68
North Carolina	51.8	+10.1	Sloan	85	14	Mount Mitchell	13	4	7.85	+4.04	Highlands	14.25	Willard	3.33
North Dakota	−8.3	−14.9	3 stations	38	[1] 3	3 stations	−44	[1] 7	.67	+.22	Fullerton	2.41	Dunn Center	.04
Ohio	35.9	+7.4	do	72	8	Holgate	−9	23	9.42	+6.31	Fernbank	14.88	Montpelier	4.58
Oklahoma	32.4	−5.4	Smithville	76	8	2 stations	−8	[1] 6	2.22	+.79	Grove	7.81	Boise City	.07

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, January 1937*—Continued

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Oregon	17.7	−13.9	Spray	56	15	Austin	−52	8	3.64	−0.23	Valsetz	15.50	Lake	0.26
Pennsylvania	36.7	+8.2	Uniontown	71	8	Corry	5	24	6.36	+3.08	Lycippus	10.54	Lawrenceville	2.63
South Carolina	55.4	+9.6	Kingstree	85	25	Caesars Head	23	4	6.84	+3.24	Caesars Head	14.39	Effingham	3.43
South Dakota	1.0	−15.6	Hot Springs	47	12	Pollock	−36	22	.83	+.28	Aberdeen	2.23	Oelrichs	.04
Tennessee	48.0	+8.8	Dickson	80	14	Newbern	12	23	14.74	+9.83	McKenzie	23.90	Erwin	5.98
Texas	45.8	−2.4	Riogrande	92	17	Dalhart	−4	[1] 8	2.14	+.45	Lufkin	11.67	3 stations	.00
Utah	10.3	−14.7	2 stations	47	[1] 29	Lewiston	−44	21	1.69	+.48	Silver Lake	5.62	Manila	.08
Virginia	45.5	+8.9	Diamond Spring	79	18	Mountain Lake	13	4	8.01	+4.67	Pennington Gap	12.34	Woodstock	4.30
Washington	17.3	−13.2	Mottinger	50	4	Deer Park (near)	−42	20	2.79	−2.44	Berne	12.01	Oroville	.37
West Virginia	43.2	+10.4	2 stations	78	[1] 8	2 stations	11	[1] 5	8.50	+4.77	Huntington	12.07	McNeill	4.04
Wisconsin	12.2	−2.8	3 stations	44	[1] 13	Hatfield	−41	10	2.25	+1.03	Shawano	3.94	Weyerhauser	.71
Wyoming	4.9	−14.9	2 stations	50	[1] 15	West Yellowstone	−56	21	.62	−.17	Bechler River	6.68	2 stations	T
Alaska (December)	3.4	−2.6	Wrangell	57	1	Fort Yukon	−65	[1] 22	3.13	+.36	Baranof	27.73	Barrow	.00
Hawaii	68.3	−.4	Mana Pump	89	27	Kanalohuluhulu	38	7	15.65	+4.98	Piihonua	59.00	Kekaha	.64
Puerto Rico	71.5	−.9	Juncos	90	[1] 2	Guineo Reservoir	42	[1] 6	10.22	+6.76	La Mina (El Yunque).	39.75	Central San Francisco.	.97

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau stations, January 1937*

[Compiled by Morton J. Serlin, by official authority, U. S. Weather Bureau]

District and station	Elevation of instruments			Pressure			Temperature of the air									Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation			Wind					Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range				Total	Departure from normal	Days with 0.01 inch, or more	Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
New England							**32.6**	**+9.3**										78	**4.03**	**+0.6**										**7.0**		
Eastport	76	67	85	30.14	30.23	+0.23	28.4	+8.0	49	3	36	1	27	20	30	27	24	82	3.05	−.9	13	11.2	nw.	30	e.	3	7	8	16	6.6	9.2	0.1
Greenville, Maine	1,070	6	40	28.98	30.22		19.8		48	9	31	−10	27	8	38	18	16	90	3.64		13	7.4	nw.	26		9	7	11	13	5.6	11.0	9.0
Portland, Maine	103	82	117	30.12	30.25	+.20	31.6	+9.2	55	9	39	10	27	24	27	28	22	70	4.64	+.7	16	8.0	n.	19	ne.	2	12	1	18	5.9	5.6	T
Concord	289	60	79				29.6	+8.0	62	15	39	6	28	20	28				3.44	+.4	14		nw.				7	8	16		12.8	
Burlington	403	11	48	29.76	30.23	+.18	27.6	+8.8	57	9	36	0	27	20	27	25	21	77	1.63	−.1	13	12.1	s.	37	s.	21	4	6	21	7.5	4.4	2.2
Northfield	876	12	60	29.25	30.24	+.19	26.3	+11.1	62	9	36	−1	28	17	31	24	19	76	2.37	.0	14	9.2	s.	30	s.	14	6	5	20	7.2	5.6	1.5
Boston [1]	29	31	50	30.22	30.25	+.20	37.4	+9.5	64	9	45	15	28	30	28	33	28	71	3.93	+.3	15	10.4	w.	30	s.	3	6	5	20	7.3	2.0	.0
Nantucket	12	14	90	30.24	30.24	+.20	40.0	+8.7	56	3	45	25	28	35	24	37	34	84	4.00	+.3	16	16.2	sw.	39	s.	31	4	4	23	8.3	1.5	.0
Block Island	26	11	46	30.22	30.25	+.18	39.5	+8.5	54	3	45	24	28	34	24	37	35	85	4.51	+.7	17	17.4	sw.	39	se.	17	4	5	22	7.8	3.1	.0
Providence	160	215	251	30.08	30.26	+.20	37.6	+10.4	65	9	45	14	28	30	29	34	30	75	4.61	+.9	14	10.9	nw.	32	nw.	16	8	4	19	7.1	3.5	.0
Hartford	159	70	104	30.09	30.27	+.20	35.8	+10.3	64	9	43	13	28	29	23				5.81	+1.9	14	8.0	n.	23	nw.	16	8	6	17	6.8	4.2	.0
New Haven	106	74	153	30.15	30.28	+.20	37.6	+9.4	64	9	44	17	28	31	29	34	28	73	6.68	+2.7	15	9.3	n.	27	sw.	18	6	6	19	7.4	4.3	.0
Middle Atlantic States							**41.7**	**+9.6**										80	**6.09**	**+2.8**										**8.3**		
Albany	97	97	112	30.16	30.27	+.20	33.0	+9.9	55	15	40	11	28	26	24	29	24	74	2.61	+.2	18	7.9	s.	27	s.	14	7	5	19	7.4	5.4	.5
Binghamton	871	57	79	29.27	30.24	+.16	33.3	+9.2	63	8	41	6	24	26	33				4.13	+1.7	16	6.7	nw.	24	se.	2	3	8	20	8.1	6.9	.0
New York	314	415	454	29.91	30.26	+.16	40.4	+9.5	65	15	47	24	27	34	24	36	31	72	6.01	+2.4	15	14.0	n.	41	sw.	15	5	6	20	7.6	3.9	.0
Harrisburg	374	94	104	29.84	30.26	+.16	37.7	+8.7	67	15	44	22	28	32	27	34	30	78	5.34	+2.2	18	7.0	ne.	28	sw.	15	2	6	23	8.7	3.7	.0
Philadelphia	114	174	367	30.14	30.27	+.16	41.4	+8.8	67	9	48	25	17	35	26	39	35	80	5.71	+2.4	16	13.1	sw.	36	s.	15	2	5	24	8.4	.4	.0
Reading	323	283	306	29.90	30.27		38.8	+9.4	68	15	45	23	28	33	29	35	31	77	5.05	+1.5	16	10.6	nw.	38	sw.	15	2	8	21	8.1	1.7	.0
Scranton	805	72	104	29.37	30.26	+.17	35.4	+8.8	66	15	42	17	24	28	31	32	27	74	4.18	+1.2	19	6.4	sw.	26	nw.	15	2	12	17	7.5	4.0	.0
Atlantic City	52	37	172	30.20	30.26	+.15	43.4	+10.9	61	9	49	28	27	38	23	41	38	81	6.88	+3.4	18	17.2	n.	42	ne.	20	0	4	27	9.3	.0	.0
Sandy Hook	22	10	57	30.23	30.25		40.4	+9.1	63	15	45	28	27	35	22	38	35	82	4.61	+.6	15	15.1	ne.	41	sw.	15	5	5	21	7.7	1.5	.0
Trenton	190	88	106	30.06	30.27		39.7	+9.2	67	9	46	23	28	33	26	38	35	85	5.43	+2.1	15	9.7	n.	31	s.	15	3	8	20	7.7	1.7	.0
Baltimore	123	100	215	30.13	30.26	+.14	43.5	+9.7	75	9	50	28	27	37	27	40	35	75	6.74	+3.2	17	10.4	ne.	30	sw.	18	3	2	26	8.5	.0	.0
Washington	112	62	85	30.13	30.26	+.13	43.8	+10.4	76	9	50	29	27	37	23	40	36	76	7.83	+4.3	18	7.4	ne.	21	nw.	18	2	5	24	8.5	T	.0
Cape Henry	18	8	54	30.22	30.24		51.9	+11.7	78	18	58	34	5	45	29	49	47	87	5.88	+2.7	20	13.6	ne.	54	n.	29	1	1	29	8.9	T	.0
Lynchburg	686	148	184	29.51	30.27	+.14	45.3	+7.8	74	10	53	25	5	38	35	42	39	82	8.49	+5.1	19	7.5	sw.	24	sw.	14	1	6	24	8.6	.0	.0
Norfolk	91	80	125	30.15	30.26	+.13	51.8	+11.2	77	18	59	37	5	45	30	48	46	85	8.46	+5.4	21	11.4	ne.	42	n.	29	1	0	30	9.4	.0	.0
Richmond	144	11	52	30.11	30.26	+.12	46.4	+8.5	72	10	53	28	5	40	32	44	41	85	10.08	+6.9	22	9.4	ne.	26	sw.	18	2	2	27	9.0	.0	.0
Wytheville	2,304	49	55		30.20	+.06	42.9	+9.9	71	22	51	22	5	35	34			84	6.05	+3.0	19	6.5	e.	27	w.	3	2	6	23			
South Atlantic States							**56.0**	**+11.3**										88	**5.56**	**+1.6**										**8.4**		
Asheville	2,253	89	104	27.82	30.20	+.05	49.6	+14.2	74	10	56	26	4	43	28	46	43	83	6.87	+3.8	17	10.4	se.	25	se.	17	0	11	20	8.3	.0	.0
Charlotte	779	63	86	29.38	30.20	+.09	49.4	+8.2	74	22	56	31	28	43	29	47	45	86	7.74	+3.7	20	8.4	ne.	25	sw.	22	0	3	28	9.2	.0	.0
Greensboro [1]	886	6	56	29.27	30.20		46.0		70	10	52	28	4	40	27	44	42	90	8.24		23	9.7	ne.	26	ne.	28	1	4	26	9.3	.0	.0
Hatteras	11	5	50		30.22	+.08	59.4	+12.3	74	14	65	46	6	54	21			90	5.77	+1.4	19	15.6	sw.	66	n.	29	5	7	19		.0	.0
Raleigh	376	103	146	29.82	30.23	+.10	50.8	+9.7	74	23	58	34	28	44	34	49	48	92	7.14	+3.5	23	9.6	ne.	32	n.	28	1	4	26	8.8	.0	.0
Wilmington	72	73	107	30.15	30.23	+.09	59.6	+13.1	80	23	68	39	28	52	26	55	53	88	4.26	+1.0	17	9.6	ne.	27	s.	15	0	9	22	8.2	.0	.0
Charleston	48	11	92	30.15	30.20	+.05	61.7	+11.8	82	23	68	43	29	56	20	58	57	90	3.91	+.9	14	10.3	sw.	29	ne.	27	1	7	23	8.5	.0	.0
Columbia, S. C.	347	70	91	29.84	30.23	+.08	56.0	+10.0	78	23	63	35	28	49	28	52	49	84	4.10	+.7	21	9.0	ne.	25	sw.	15	1	8	23	8.5	.0	.0
Greenville, S. C.	1,039	139	146				49.8	+9.5	72	23	56	32	28	43	28				8.12		21		ne.				2	5	24		.0	.0
Augusta	182	62	77	30.00	30.19	+.03	57.9	+10.9	79	22	65	36	28	51	24	54	52	86	4.22	+.3	22	6.3	ne.	21	sw.	18	2	6	24	8.6	.0	.0
Savannah	65	73	152	30.12	30.19	+.04	64.0	+12.6	82	25	71	43	29	57	22	59	57	90	1.84	−.9	12	10.4	s.	25	sw.	18	2	9	20	7.9	.0	.0
Jacksonville	43	86	110	30.13	30.18	+.03	67.5	+12.1	83	20	74	44	29	60	21	62	61	90	4.52	+1.7	10	7.8	s.	22	ne.	27	5	13	13	6.7	.0	.0

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, January 1937*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Florida Peninsula							74.0	+9.5										82	1.05	−1.1										4.4		
Key West	22	10	64	30.06	30.08	−.02	77.0	+7.5	84	28	81	70	23	73	13	70	68	81	.84	−1.1	12	11.6	e.	20	e.	20	15	14	2	3.7	0.0	0.0
Miami	25	124	168	30.10	30.13	.00	75.4	+8.9	82	27	78	68	31	73	11	69	67	78	1.30	−1.2	10	11.8	e.	24	e.	9	9	18	4	4.8	.0	.0
Tampa	35	88	197	30.10	30.14	+.02	72.4	+12.0	85	5	80	56	29	64	26	66	64	87	1.72	−1.0	6	10.7	se.	23	s.	22	5	21	5	5.8	.0	.0
Titusville	43	5	36	30.10	30.15		71.3		85	25	80	54	31	62	26				.35		9		se.				11	16	4		.0	.0
East Gulf States							59.9	+11.3										87	7.19	+2.5										8.6		
Atlanta [1]	976	5	53	29.13	30.17	+.02	53.0	+10.4	76	24	60	32	4	46	21	50	48	89	8.88	+3.9	18	9.0	e.	25	sw.	22	0	3	28	9.2	.0	.0
Macon	370	79	87	29.78	30.18	+.02	58.8	+12.0	79	23	66	37	28	52	24	55	52	85	4.21	.0	18	7.2	s.	21	ne.	28	1	6	24	8.5	.0	.0
Thomasville	273	49	58	29.85	30.16	.00	64.7	+13.7	80	9	72	40	29	57	25	60	58	89	4.47	+.4	11		s.				0	8	23		.0	.0
Apalachicola	35	11		30.10	30.14		64.6	+10.9	76	22	69	45	29	60	16	62	61	92	1.31	−2.3	11	9.5	se.	25	e.	28	0	9	22	8.1	.0	.0
Pensacola	56	149	185	30.06	30.12	−.02	63.2	+10.7	76	31	68	46	29	59	17	62	60	91	2.17	−1.8	15	13.8	se.	29	se.	31	2	19	10	6.9	.0	.0
Anniston	741	9					57.2	+15.0	78	22	65	29	4	50	26				9.30	+4.2	25		s.				2	8	21		.0	.0
Birmingham	700	11	48	29.36	30.13	−.03	56.4	+11.3	78	22	63	31	4	50	27	53	50	86	13.37	+7.8	20	9.2	se.	25	s.	14	0	4	27	9.0	.0	.0
Mobile	57	86	105	30.04	30.10	−.05	63.8	+11.5	78	31	69	45	4	57	20	60	58	88	4.03	−.8	12	10.8	s.	25	sw.	2	0	4	27	8.8	.0	.0
Montgomery	218	92	105	29.90	30.15	−.01	60.4	+12.2	81	22	67	39	4	53	22	57	54	85	4.66	−.5	16	8.3	e.	21	sw.	18	0	6	25	8.7	.0	.0
Meridian	375	67	92	29.70	30.11	−.05	57.6	+10.6	80	22	66	34	4	50	31	54	52	84	18.77	+13.4	20	8.0	s.	22	sw.	17	0	3	28	9.1	.0	.0
Vicksburg	247	65	73	29.83	30.10	−.05	54.7	+6.5	79	22	63	30	23	46	41	51	48	83	11.19	+5.8	21	8.4	n.	22	s.	20	0	6	25	9.0	.0	.0
New Orleans	53	76	84	30.02	30.08	−.05	65.5	+11.3	83	18	72	48	4	59	25	62	60	87	3.93	−.4	19	8.2	se.	19	se.	7	0	5	26	8.7	.0	.0
West Gulf States							48.4	−0.2										86	4.49	+1.7										8.1		
Shreveport	249	92	227	29.80	30.08	−.06	50.2	+3.2	77	7	58	29	23	43	32	47	45	85	8.39	+4.5	21	10.8	ne.	34	nw.	14	2	5	24	8.7	.0	.0
Bentonville	1,303	12	38	28.71	30.11	−.03	33.1	−1.0	59	20	42	10	22	24	29				7.05	+4.4	14	7.5	e.	24	w.	8	3	8	20		8.9	T
Fort Smith	457	79	94	29.59	30.09	−.05	37.7	−1.8	62	20	45	19	23	31	27	35	32	81	4.41	+1.9	13	8.7	e.	25	w.	2	3	4	24	8.2	1.0	.0
Little Rock	357	94	102	29.72	30.11	−.04	41.8	+.4	71	7	49	20	23	35	38	40	37	86	18.04	+13.3	19	8.4	e.	24	nw.	8	3	1	27	8.8	T	.0
Austin	605	136	148	29.40	30.04		47.6	−1.9	78	7	55	25	9	40	44	45	43	86	2.43	+.4	22	7.6	n.	27	s.	7	1	7	23	8.7	.0	.0
Brownsville	57	88	96	29.89	29.95		61.4	+1.6	79	7	67	37	23	56	36	59	58	90	2.09	+.6	17	12.0	nw.	34	se.	21	0	8	23	8.7	.0	.0
Corpus Christi	20	11	78	29.97	29.99	−.11	57.2	+1.2	80	20	64	33	10	51	37	54	52	88	.42	−1.1	12	11.2	n.	35	s.	21	0	0	31	9.4	.0	.0
Dallas	512	220	227	29.50	30.06		41.8		68	30	50	19	9	34	36	39	36	85	1.50	−.9	17	10.8	nw.	31	w.	14	2	6	23	8.5	2.0	.0
Fort Worth	679	92	110	29.33	30.07	−.05	41.0	−4.4	75	30	49	18	9	33	37				1.71	−.3	13	9.3	n.	29	n.	22	2	5	24	8.3	4.2	.0
Galveston	54	106	114	29.97	30.03	−.10	57.2	+3.4	72	21	62	37	22	52	33	56	55	93	3.34	−.1	16	11.6	n.	26	s.	17	2	7	22	8.2	.0	.0
Houston	138	292	314	29.89	30.04		53.4	+.7	76	6	61	30	22	46	40				3.25	−.4	26	12.8	n.	32	se.	7	0	6	25	8.9	.0	.0
Palestine	510	64	72	29.52	30.07	−.05	46.9	−1.3	73	7	55	24	23	39	45	45	43	88	4.88	+1.4	20	7.8	n.	25	s.	13	2	3	26	9.1	.0	.0
Port Arthur	34	58	66	29.99	30.03		57.2		73	14	64	39	23	51	33				4.43	+.7	18	11.4	n.	31	se.	18	0	8	23	8.5	.0	.0
San Antonio	693	242	301	29.28	30.01	−.09	50.4	−1.9	81	7	59	26	23	42	48	47	44	82	.96	−.5	22	10.0	n.	33	se.	7	0	4	27	9.0	.0	.0
Ohio Valley and Tennessee							41.3	+8.2										82	12.06	+8.3										8.4		
Chattanooga	762	71	214	29.34	30.16	.00	53.3	+12.1	77	22	60	30	4	47	26	49	46	79	11.00	+5.7	20	9.2	se.	25	se.	2	1	7	23	8.4	0.0	0.0
Knoxville	995	66	84	29.09	30.16	+.01	51.4	+12.6	76	22	59	27	4	44	29	48	45	83	11.63	+7.0	18	6.7	ne.	22	se.	2	1	9	21	8.3	.0	.0
Memphis	399	78	86	29.68	30.11	−.05	44.4	+3.5	75	14	51	19	23	38	29	42	40	86	17.56	+12.8	20	8.5	n.	34	nw.	14	1	3	27	8.9	.0	.0
Nashville	546	168	188	29.57	30.16	.00	47.0	+8.4	73	21	55	27	16	39	33	44	42	84	14.75	+10.0	21	10.8	s.	32	nw.	14	2	4	25	9.0	.0	.0
Lexington	989	6	230				41.7	+8.8	71	8	50	21	4	34	34				15.10	+11.9	20		ne.				3	6	22		.2	.0
Louisville	525	188	234	29.59	30.19	+.05	40.2	+5.8	67	20	48	18	23	33	31	38	34	81	19.17	+15.2	19	11.2	n.	30	s.	14	3	3	25	8.6	T	.0
Evansville	431	76	116	29.68	30.16	+.02	38.1	+4.6	64	8	45	13	23	31	28	36	33	81	14.78	+11.0	18	10.4	n.	32	sw.	14	3	2	26	8.6	7.0	.0
Indianapolis	822	194	230	29.25	30.16	+.04	33.2	+4.8	60	14	41	4	23	25	32	31	28	81	8.05	+5.1	16	11.8	s.	33	w.	2	4	4	23	8.3	4.0	.0
Terre Haute	575	63	149	29.51	30.15		33.0		60	8	41	1	23	25	31	31	28	83	8.99	+6.3	15	10.4	sw.	30	sw.	4	5	5	21	7.5	4.2	.0
Cincinnati	627	11	51	29.49	30.20	+.08	38.6	+8.3	67	8	47	17	23	30	31	36	33	84	13.68	+10.2	16	8.7	sw.	24	w.	21	2	4	25	8.6	6.0	.0
Columbus	822	90	210	29.28	30.18	+.07	37.8	+9.2	66	8	46	17	23	30	28	35	31	79	10.71	+7.6	15	10.6	s.	37	s.	14	3	6	22	8.2	4.2	.0
Dayton	900	58	153	29.15	30.17		37.2	+7.7	64	8	45	13	23	29	30				12.41	+9.2	15	9.7	sw.	29	sw.	8	3	4	24	8.4	4.4	.0
Elkins	1,947	59	78	28.12	30.24	+.12	43.4	+13.0	72	8	53	18	27	34	33	39	36	84	6.92	+3.1	19	7.1	se.	35	sw.	22	2	10	19	8.0	.0	.0
Parkersburg	637	77	84	29.55	30.22	+.10	41.9	+9.4	71	8	51	24	27	33	35	38	35	81	8.99	+5.4	20	7.1	se.	28	nw.	21	2	6	23	8.4	2.0	.0
Pittsburgh [1]	1,273	39	54	28.79	30.18	+.07	37.7	+7.0	66	8	46	18	27	30	36	35	31	80	7.15	+4.1	18	11.9	nw.	35	n.	21	1	8	22	8.3	2.9	.0
Lower Lake Region							32.2	+7.8										79	4.70	+2.1										7.8		
Buffalo	768	243	280	29.32	30.18	+.11	32.4	+7.8	57	9	40	14	24	25	30	30	27	81	4.42	+1.1	19	19.2	sw.	57	sw.	3	1	10	20	8.2	9.7	.0
Canton	448	10	61	29.70	30.20		27.3	+11.0	55	9	36	−1	27	18	26	25	22	84	3.95	+1.4	17	11.4	w.	34	w.	5	2	11	18	8.0	4.3	.0
Ithaca	836	77	100	29.29	30.23		32.2	+7.9	63	8	40	10	23	25	29	29	26	77	3.66	+1.5	15	11.1	se.	34	se.	20	3	5	23	8.2	7.4	.0
Oswego	335	71	85	29.83	30.22	+.15	32.2	+8.3	62	9	39	9	27	25	30	29	24	74	3.44	+.5	18	11.8	s.	27	s.	13	2	6	23	8.4	6.8	.0
Rochester	523	86	102	29.62	30.21	+.14	33.2	+8.6	65	9	40	16	24	26	35	30	24	71	3.13	+.2	20	10.4	sw.	28	w.	31	2	12	17	7.6	7.4	.0
Syracuse	596	65	79	29.56	30.22	+.15	33.8	+9.7	64	9	42	9	27	26	36				3.68	+.6	18	8.8	w.	26	s.	14	3	6	22	7.9	10.9	.0
Erie	714	130	166	29.39	30.18	+.10	34.8	+8.0	64	8	42	17	24	27	34	31	27	76	6.05	+3.3	18	15.3	w.	53	se.	2	2	11	18	7.9	7.1	.0
Cleveland	762	267	318	29.33	30.17	+.08	35.8	+9.3	66	8	44	18	24	27	37	32	29	80	6.58	+4.1	17	16.5	se.	43	se.	2	3	5	23	8.2	5.3	.0
Sandusky	629	5	67	29.47	30.18	+.09	34.2	+7.9	63	8	42	15	26	26	39				6.58	+4.3	17	10.8	sw.	28	sw.	3	3	9	19	7.7	5.1	.0
Toledo	628	79	87	29.48	30.18	+.09	31.2	+5.4	60	8	39	7	23	24	36	29	26	82	5.36	+3.2	16	10.8	w.	31	w.	2	7	5	19	7.0	4.8	T
Fort Wayne	857	69	84	29.22	30.17		30.0	+3.8	57	8	38	7	23	22	33	28	26	87	5.96	+3.6	15	10.2	w.	30	s.	4	9	4	18	6.9	7.5	.0
Detroit [1]	626	5	78	29.46	30.17	+.09	29.7	+5.3	58	8	38	3	23	22	31	28	24	81	3.64	+1.6	17	11.8	sw.	34	sw.	3	7	5	19	7.2	4.4	.0
Upper Lake Region							20.3	+1.9										81	2.44	+0.6										6.7		
Alpena	609	13	89	29.43	30.12	+.08	24.0	+4.9	46	14	32	−2	27	16	28	22	17	76	1.55	−.3	10	13.3	w.	41	se.	20	7	6	18	6.5	6.4	.7
Escanaba	612	54	60	29.40	30.10	+.05	14.6	−.8	37	14	26	−13	27	3	39	14	11	83	2.70	+1.2	11	9.9	sw.	25	s.	4	10	4	17	6.1	23.5	12.3
Grand Rapids	707	70	244	29.34	30.14	+.08	28.6	+4.1	55	8	36	13	23	21	25	25	22	79	2.15	−.2	14	13.4	w.	43	sw.	3	6	3	22	7.6	6.3	.2
Lansing	878	5	90	29.17	30.14		27.4	+5.0	55	8	35	3	23	19	31	25	23	89	2.05	+.2	13	10.9	sw.	27	sw.	4	6	6	19	7.3	3.7	T
Ludington	637	5	54	29.39	30.11		25.6	+2.5	44	8	33	3	27	18	28	23			2.51	+.4	16		w.				4	6	21		8.9	.8
Marquette	734	77	111	29.23	30.07	+.03	16.0	−.3	36	14	25	−4	19	7	32	15	12	85	2.41	+.1	15	11.0	w.	42	sw.	11	7	5	19	7.2	23.9	14.0
Sault Sainte Marie	614	11	52	29.39	30.12	+.09	18.3	+5.0	38	14	27	−6	10	9	37	16	13	83	3.61	+1.7	24	10.0	se.	32	nw.	31	2	7	22	8.2	30.1	22.3
Chicago	673	7	131	29.40	30.15	+.05	26.9	+3.2	57	8	34	5	23	19	37	24	20	77	2.29	+.4	9	11.7	w.	34	sw.	2	9	5	17	6.4	2.4	.0
Green Bay	617	109	141	29.40	30.10	+.04	15.2	−.5	38	14	25	−14	23	5	34	14	10	77	2.43	+.9	8	11.8	sw.	32	sw.	4	10	5	16	6.4	12.8	6.4
Milwaukee	681	97	221	29.35	30.12	+.04	23.1	+2.5	44	13	31	−1	23	15	28	21	16	75	3.12	+1.3	9	14.7	w.	38	e.	20	10	3	18	6.2	.7	.1
Duluth	1,133	5	47	28.79	30.09	.00	3.3	−4.6	28	27	14	−24	26	−7	34	2	−1	82	1.99	+1.0	12	14.2	nw.	46	nw.	4	13	5	13	5.5	21.4	12.2
North Dakota							−8.1	−12.6										81	0.83	+0.2										5.7		
Moorhead, Minn.	940	50	58	29.08	30.18	+.04	−6.1	−9.9	33	4	3	−33	22	−15	51	−6	−8	91	1.55	+.9	14	9.0	n.	27	nw.	4	3	11	17	7.5	27.3	14.0
Bismarck	1,674	8	57	28.25	30.19	+.06	−6.0	−13.8	34	3	3	−37	22	−15	52	−7	−12	74	.70	+.2	10	7.7	nw.	30	n.	4	10	10	11	5.5	13.8	8.4
Devils Lake	1,478	11	44	28.48	30.19	+.07	−9.9	−11.7	31	4	0	−33	22	−19	55	−11	−14	82	.47	.0	12	8.5	nw.	30	n.	4	8	12	11	5.7	6.3	4.8
Grand Forks	833	12	67				−9.7		26	4	0	−36	22	−20	47	−10			.94		12		nw.	39	nw.	4	5	11	15		13.5	13.1
Williston	1,878	2	50	28.06	30.19	+.08	−8.6	−15.0	35	3	1	−38	7	−18	54	−9	−13	77	.50	.0	10	6.6	sw.	30	nw.	3	17	6	8	4.0	5.3	8.5

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, January 1937*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet weather	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*		*° F.*	*° F.*		*° F.*	*° F.*	*° F.*	*° F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Upper Mississippi Valley							**19.4**	**−2.3**										**81**	**4.17**	**+2.5**										**6.0**		
Minneapolis	919	105	208	29.06	30.10	.....	5.4	−7.3	35	4	16	−18	22	−5	44	5	2	85	1.24	+.4	11	11.4	w.	32	w.	4	12	6	13	5.1	12.2	9.2
La Crosse	714	11	48	29.32	30.14	+.03	10.0	−6.1	40	4	22	−23	23	−2	39	9	5	79	2.48	+1.4	11	5.6	s.	18	w.	4	13	5	13	5.3	23.1	12.4
Madison	974	70	78	29.02	30.14	+.04	16.3	−.4	39	13	25	−7	22	7	34	15	12	85	3.31	+1.9	9	9.4	w.	25	sw.	4	9	8	14	6.1	6.6	2.5
Charles City	1,015	10	51	29.00	30.15	+.01	6.9	−6.8	38	4	18	−24	23	−5	41	6	3	84	2.41	+1.4	9	7.8	se.	22	w.	2	17	3	11	4.6	19.0	13.0
Davenport	606	66	161	29.47	30.17	+.05	20.4	−1.4	42	13	29	0	23	12	32	19	15	78	3.52	+2.1	9	11.2	nw.	33	sw.	2	10	4	17	6.2	2.6	1.5
Des Moines	861	5	99	29.20	30.17	+.03	14.6	−5.5	41	4	24	−6	9	5	37	13	9	80	1.85	+.8	10	10.9	nw.	33	w.	2	12	10	9	4.8	4.0	.8
Dubuque	699	60	79	29.36	30.16	+.04	16.6	−2.5	39	4	26	−6	9	7	35	15	11	76	3.44	+2.1	8	7.1	nw.	20	nw.	4	12	5	14	5.8	3.2	3.1
Keokuk	614	64	78	29.48	30.17	+.03	21.9	−3.0	46	6	30	−1	23	14	31	20	14	70	3.36	+1.8	10	8.1	nw.	30	sw.	2	10	1	20	6.5	3.3	T
Cairo	358	87	93	29.75	30.14	−.02	39.2	+4.3	67	14	46	13	23	32	31	37	35	87	15.45	+11.7	16	11.0	n.	30	n.	21	5	1	25	8.4	T	.0
Peoria	609	11	45	29.48	30.17	+.05	23.8	+.7	47	2	32	−8	23	15	30	22	20	85	2.86	+1.1	9	8.4	w.	27	sw.	2	10	5	16	5.9	4.7	.0
Springfield, Ill	636	5	191	29.46	30.16	+.03	27.3	+.8	58	8	35	0	23	20	40	25	22	82	4.95	+2.8	13	12.3	se.	34	sw.	2	11	4	16	6.3	4.7	.0
St. Louis	568	179	303	29.52	30.15	+.01	30.7	−.4	62	8	39	4	23	23	44	28	25	80	5.21	+2.9	13	11.9	nw.	35	s.	8	8	7	16	6.7	2.1	.0
Missouri Valley							**15.8**	**−8.2**										**81**	**2.48**	**+1.4**										**5.5**		
Columbia, Mo	784	6	64	29.28	30.15	+.02	25.8	−3.4	51	20	34	−6	23	18	29	.....	.....	.....	4.03	+2.1	11	9.0	se.	27	sw.	2	10	3	18	6.2	5.0	.0
Kansas City [1]	750	32	45	29.31	30.15	.00	23.0	−5.2	56	6	32	1	9	14	44	20	16	77	3.37	+2.2	9	10.3	n.	39	w.	2	9	16	16	6.3	3.6	1.5
St. Joseph	967	11	49	29.06	30.15	.....	20.6	.....	50	1	30	−2	9	12	44	17	13	76	2.59	+1.3	8	10.0	nw.	35	w.	2	11	9	11	5.3	.5	.2
Springfield, Mo	1,324	93	104	28.66	30.11	−.03	30.2	−3.3	60	8	38	7	22	22	48	28	26	84	6.94	+4.6	15	10.6	se.	29	w.	8	7	8	16	6.8	8.1	T
Topeka	987	65	87	29.04	30.14	.....	22.2	−5.4	54	6	31	0	8	14	46	19	15	77	1.82	+.9	7	10.0	nw.	27	w.	2	9	11	11	5.6	T	T
Lincoln	1,189	11	81	28.81	30.15	.00	13.2	−9.6	44	4	23	−12	9	3	36	12	8	79	1.37	+.7	9	11.1	s.	34	nw.	2	15	5	11	4.5	10.0	3.6
Omaha [1]	982	31	44	29.05	30.16	+.01	11.0	−10.9	42	4	22	−18	9	0	35	10	6	82	1.15	+.4	8	12.3	nw.	41	nw.	2	14	8	9	4.8	14.1	4.7
Valentine	2,598	47	54	27.28	30.18	+.06	5.8	−13.1	39	13	17	−17	7	−6	46	4	1	83	.41	−.1	9	9.4	w.	24	nw.	20	11	7	13	5.7	8.2	5.6
Sioux City	1,138	64	106	28.86	30.16	+.01	6.4	−11.4	40	4	16	−16	22	−3	36	6	3	84	1.64	+.9	6	11.6	nw.	38	nw.	2	13	7	11	5.5	17.9	10.5
Huron	1,307	59	74	28.68	30.18	+.02	.0	−11.3	36	4	9	−22	9	−9	45	−1	−3	89	1.51	+1.0	10	10.3	nw.	28	w.	4	14	9	8	4.6	19.9	8.7
Northern Slope							**3.0**	**−16.6**										**77**	**0.72**	**0.0**										**5.9**		
Havre	2,505	11	67	27.38	30.22	+.12	−2.8	−15.7	35	12	8	−36	30	−13	41	−4	−6	85	.99	+.3	16	10.4	w.	39	sw.	3	9	6	16	6.5	12.9	12.6
Helena	4,124	85	111	25.75	30.24	+.09	−2.4	−22.6	33	4	6	−30	7	−11	40	−3	−7	78	.84	.0	12	6.0	nw.	34	sw.	3	8	3	20	7.0	15.0	9.0
Missoula	3,263	80	91	.....	.....	.....	4.6	−17.7	33	4	12	−26	7	−3	26	.....	.....	.....	.75	−.3	17	8.5	se.	47	e.	4	5	4	22	7.7	12.6	6.0
Kalispell	2,973	48	56	26.96	30.24	+.12	1.0	−19.4	28	26	9	−27	20	−7	24	2	0	93	2.12	+.6	21	5.8	w.	26	ne.	26	4	5	22	7.8	34.2	14.9
Miles City	2,371	48	55	27.49	30.23	+.11	−1.8	−16.3	37	3	8	−31	7	−12	43	−3	−11	63	.38	−.3	9	6.7	s.	30	nw.	24	9	14	8	5.5	5.4	5.3
Rapid City	3,259	50	58	26.54	30.20	+.10	6.0	−16.0	45	12	17	−17	7	−5	47	5	3	85	.35	−.1	8	7.0	n.	28	n.	24	12	9	10	5.1	6.4	2.1
Cheyenne [1]	6,144	5	39	23.71	30.01	−.04	12.7	−12.8	48	12	25	−26	8	1	40	9	1	61	.47	.0	7	12.4	nw.	49	w.	3	12	13	6	4.6	5.6	.5
Lander	5,372	60	68	24.46	30.14	+.02	1.0	−17.3	36	4	14	−31	9	−12	42	0	−5	81	.39	−.2	6	3.8	sw.	19	w.	4	16	12	3	3.8	5.1	5.5
Sheridan	3,790	10	47	26.00	30.15	.....	2.7	.....	39	3	14	−20	7	−9	36	1	−4	72	.19	−.7	9	5.2	nw.	24	nw.	2	8	13	10	5.6	2.1	1.9
Yellowstone Park	6,241	12	46	23.67	30.16	+.02	2.2	−15.5	27	12	12	−30	6	−8	36	0	−6	69	.83	+.1	15	8.0	s.	34	sw.	15	6	5	20	6.9	15.4	6.5
North Platte	2,821	11	51	27.04	30.15	+.03	10.2	−12.7	43	13	22	−14	7	−1	43	8	5	84	.62	+.2	11	7.7	w.	23	nw.	2	14	8	9	4.5	7.7	1.7
Middle Slope							**22.3**	**−8.2**										**74**	**0.96**	**+0.4**										**5.0**		
Denver	5,292	106	113	24.53	30.00	−0.05	18.2	−11.6	49	26	29	−12	7	8	35	14	5	60	.29	−0.1	6	6.7	s.	28	nw.	17	16	12	3	3.5	6.0	T
Pueblo	4,685	80	86	25.13	29.97	+.08	23.0	−6.9	55	26	37	−10	8	9	47	17	7	58	.18	−.1	4	7.9	e.	36	nw.	31	21	8	2	2.7	2.2	0.0
Concordia	1,392	50	58	28.59	30.14	.00	16.6	−9.8	46	1	25	−7	9	8	37	15	12	86	1.76	+1.2	6	9.0	n.	30	nw.	2	10	11	10	5.2	3.2	1.5
Dodge City	2,509	10	86	27.38	30.10	−.01	21.4	−7.6	50	1	32	−4	7	11	37	18	14	79	.76	+.4	4	11.1	n.	31	nw.	2	15	7	9	4.9	2.9	T
Wichita	1,358	85	93	28.62	30.12	−.01	24.3	−7.0	54	6	32	0	8	16	46	22	18	80	1.54	+.8	7	11.6	n.	26	sw.	13	7	7	17	6.7	.3	T
Oklahoma City	1,214	10	47	28.76	30.09	−.02	30.4	−6.0	60	6	38	7	8	22	44	28	25	83	1.21	.0	13	10.8	n.	26	n.	21	6	5	20	7.3	3.0	.0
Southern Slope							**39.7**	**−3.0**										**63**	**0.38**	**−0.3**										**6.1**		
Abilene	1,738	10	52	28.20	30.05	−.04	40.2	−4.0	71	6	51	13	8	30	36	35	29	72	.90	−.1	7	9.1	n.	28	s.	13	5	6	20	7.2	.3	.0
Amarillo	3,676	10	49	26.18	30.02	−.04	30.8	−4.5	64	5	43	0	8	19	41	24	14	58	.29	−.2	2	9.7	s.	28	w.	17	14	6	11	4.6	3.1	.0
Del Rio	960	63	71	28.97	29.97	−.09	51.2	−1.1	79	7	61	24	23	41	46	47	42	75	.21	−.4	10	8.9	se.	24	se.	7	3	5	23	8.1	.0	.0
Roswell	3,566	75	85	26.29	29.97	−.07	36.7	−2.5	66	6	50	10	24	23	46	29	15	47	.11	−.4	1	7.6	s.	35	sw.	19	13	9	9	4.5	.1	.0
Southern Plateau							**33.1**	**−6.7**										**60**	**1.02**	**+0.1**										**3.6**		
El Paso	3,778	82	101	26.13	29.97	−.04	42.4	−2.6	65	29	54	20	26	30	36	34	21	45	.12	−.3	1	7.9	w.	35	sw.	7	17	11	3	3.1	.0	.0
Albuquerque [1]	4,972	5	39	24.96	30.01	.....	26.4	−7.7	52	19	40	−1	8	12	41	21	13	61	.21	−.2	1	8.0	n.	35	sw.	1	14	11	6	3.9	4.0	.0
Santa Fe	7,013	38	53	23.08	29.98	−.06	23.7	−5.1	46	11	35	0	23	13	36	19	11	59	.53	−.1	8	5.7	n.	21	se.	7	15	7	9	4.7	5.4	.0
Flagstaff	6,907	10	59	23.16	29.98	−.07	12.6	−14.1	43	4	28	−30	22	−3	58	12	.....	86	3.19	.....	14	8.0	sw.	29	sw.	19	10	11	10	.....	42.8	24.0
Phoenix	1,107	39	51	28.85	30.03	.00	43.2	−8.0	66	11	54	21	22	32	36	36	28	59	.83	.0	6	5.2	e.	27	sw.	19	16	8	7	3.9	1.0	.0
Yuma	141	9	54	29.92	30.07	+.02	44.9	−9.5	67	29	56	22	24	34	32	38	26	47	.14	−.3	3	6.7	n.	29	w.	19	22	5	4	2.5	T	.0
Independence	3,957	5	26	25.99	30.09	+.02	38.4	+.2	60	9	51	16	30	26	31	31	22	.....	2.10	+1.3	6	.....	n.	.....	.....	.....	20	5	6	.....	17.3	11.0
Middle Plateau							**12.2**	**−15.8**										**82**	**1.27**	**+.3**										**5.5**		
Reno	4,527	61	76	25.39	30.11	−.02	15.8	−15.8	46	4	26	−16	8	5	38	15	10	74	1.90	+.4	10	5.5	w.	27	w.	14	7	12	12	5.8	26.6	17.6
Tonopah	6,090	12	20	.....	.....	.....	11.6	.....	31	4	18	−15	21	5	26	10	8	90	.63	.....	10	.....	se.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnemucca	4,344	18	56	25.56	30.15	−.01	9.7	−18.9	37	17	23	−36	21	−3	42	9	7	84	1.42	+.4	13	7.6	ne.	24	sw.	17	8	6	17	6.4	25.7	16.8
Modena	5,473	10	43	24.48	30.08	−.02	7.6	−19.1	35	30	20	−32	9	−5	41	7	5	86	1.14	+.3	12	9.8	w.	32	s.	5	15	8	8	4.2	23.5	8.2
Salt Lake City [1]	4,227	32	46	25.65	30.10	−.05	13.2	−16.0	36	28	23	−20	21	3	37	12	10	83	1.76	.....	16	8.4	se.	28	sw.	15	4	10	17	7.0	32.3	16.2
Grand Junction	4,602	60	68	25.30	30.01	−.05	15.0	−9.0	42	6	26	−14	22	4	36	13	9	77	.78	+.2	7	4.8	n.	34	s.	6	15	9	7	4.3	8.4	.4
Northern Plateau							**12.8**	**−15.1**										**78**	**1.53**	**−0.1**										**6.9**		
Baker	3,471	48	53	26.40	30.15	−.01	9.4	−15.5	36	15	20	−22	6	−1	33	10	7	82	1.32	−.1	17	6.4	se.	19	sw.	15	7	4	20	7.2	26.3	9.7
Boise	2,739	79	87	27.18	30.18	−.01	15.4	−14.4	37	27	24	−15	20	7	30	15	10	77	1.60	−.1	17	5.1	se.	21	se.	27	4	10	17	7.0	25.5	8.0
Pocatello	4,477	60	68	25.38	30.12	−.08	11.0	−13.7	34	28	19	−23	9	3	30	10	6	80	1.70	+.3	17	9.5	se.	30	sw.	16	5	7	19	7.3	19.2	12.2
Spokane	1,929	101	110	28.01	30.17	+.05	9.9	−17.6	38	4	18	−19	20	2	28	10	7	82	1.94	−.2	19	5.8	ne.	26	ne.	5	8	8	15	6.2	36.0	19.0
Walla Walla	991	57	65	29.04	30.17	+.02	15.8	−16.9	49	4	23	−8	31	9	28	15	10	75	1.75	−.2	17	5.2	s.	23	se.	25	7	4	20	7.5	30.0	15.8
Yakima	1,076	58	67	29.96	30.17	.....	15.0	−12.4	42	4	23	−7	30	7	29	14	8	71	.85	−.4	13	4.5	nw.	27	ne.	5	7	12	12	6.3	10.0	6.7

[1] Observations taken at airport.

TABLE 2.—*Climatological data for Weather Bureau stations, January 1937*—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air												Precipitation			Wind										
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet weather	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01 inch, or more	Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	°F.		°F.	° F.		° F.	° F.	° F.	° F.	%	In.	In.		Miles								0-10	In.	In.
North Pacific Coast Region							31.8	−7.9										76	3.83	−2.9										6.9		
North Head	211	11	56	29.83	30.06	+.01	34.4	−7.7	46	4	30	20	6	30	17	32	28	78	4.19	−4.6	20	12.9	e.	45	nw.	4	6	8	17	6.6	8.3	1.9
Seattle	125	90	321	29.93	30.07	+.02	31.7	−7.8	43	4	36	16	20	27	16	29	23	68	2.59	−2.4	15	9.3	se.	41	sw.	3	10	4	17	6.4	10.9	1.9
Tatoosh Island	86	10	54	29.94	30.04	+.06	35.4	−5.8	46	3	38	26	6	32	12	33	28	73	2.83	−9.0	18	16.9	e.	51	e.	31	7	5	19	6.9	7.8	.2
Medford [1]	1,329	29	58	28.65	30.12	------	26.9	------	45	31	36	1	8	18	29	26	23	83	2.10	−.7	14	------	n.	------	------	------	7	5	19	7.0	9.5	.3
Portland, Oreg	153	68	106	29.93	30.10	+.02	29.9	−9.5	44	17	34	14	7	25	16	28	22	70	6.02	−.6	16	7.8	e.	24	s.	16	11	3	17	6.5	18.0	4.2
Roseburg	510	45	76	29.53	30.10	.00	32.6	−8.6	49	24	40	7	8	25	25	31	28	81	5.25	−.1	16	4.5	sw.	18	n.	6	4	6	21	7.9	7.7	.0
Middle Pacific Coast Region							36.7	−10.3										71	37.9	−1.8										5.4		
Eureka	62	73	89	30.03	30.10	.00	40.4	−6.5	51	17	47	25	8	34	19	38	34	75	4.27	−2.8	19	8.4	se.	38	n.	18	7	10	14	5.9	T	.0
Redding [1]	722	20	34	------	------	------	34.1	−11.2	51	24	40	17	20	28	24	31	24	68	2.72	−4.1	13	7.7	nw.	32	n.	6	9	8	14	6.1	19.9	T
Sacramento	66	92	115	30.02	30.10	−.02	28.7	−17.1	54	4	46	22	9	32	24	36	30	70	2.92	−.8	15	8.7	nw.	26	nw.	20	13	7	11	4.7	T	.0
San Francisco	155	112	132	29.91	30.08	−.03	43.6	−6.3	55	4	49	30	21	39	14	40	35	71	5.26	+.7	16	7.3	se.	23	n.	20	14	7	10	4.7	.0	.0
South Pacific Coast Region							45.9	−5.8										62	1.83	−0.5										4.2		
Fresno	327	97	105	29.74	30.11	+.01	40.7	−5.5	56	15	48	19	21	33	22	37	31	66	1.97	+.2	10	6.3	nw.	21	nw.	16	14	8	9	4.8	Y	.0
Los Angeles	338	159	191	29.69	30.06	−.02	47.8	−6.8	61	31	55	32	9	40	22	41	31	56	1.99	−1.1	8	6.7	ne.	21	nw.	16	19	5	7	3.3	.0	.0
San Diego	87	62	70	29.97	30.07	.00	49.2	−5.1	61	2	57	30	22	42	22	44	37	63	1.52	−.5	14	6.6	e.	26	s.	12	14	9	8	4.5	.0	.0
West Indies																																
San Juan, P. R	82	9	54	29.94	30.04	------	73.8	−1.2	79	18	78	66	31	70	12	----	----	----	15.47	+11.3	28	18.2	e.	38	e.	10	5	21	5	5.2	.0	.0
Panama Canal																																
Balboa Heights	118	6	97	------	[3] 29.80	−.04	79.8	−.1	89	6	87	68	31	72	20	----	----	[3] 81	5.07	+4.1	17	6.1	nw.	23	se.	21	3	22	6	5.9	.0	----
Cristobal	36	6	97	------	[3] 29.82	−.04	81.0	−.5	87	9	85	73	22	77	11	75	73	[3] 80	4.20	+.7	21	10.6	n.	24	ne.	10	5	16	10	6.1	.0	----
Alaska																																
Fairbanks	454	11	87	[2] 29.69	[2] 30.25	------	11.4	------	41	1	22	−26	25	0	55	13	9	76	6.71	------	23	7.4	sw.	34	sw.	6	4	2	25	8.3	65.6	54.3
Juneau	80	96	116	[2] 30.13	[2] 30.22	------	27.8	------	41	2	32	13	14	24	22	25	19	70	5.57	------	17	7.5	s.	35	ne.	31	7	3	21	7.2	21.6	5.9
Hawaiian Islands																																
Honolulu	38	86	100	[3] 29.90	[3] 29.94	------	71.0	+.1	79	3	76	62	28	66	16	65	62	75	6.96	+3.2	18	9.1	e.	35	sw.	30	8	14	9	5.4	.0	.0

[1] Observations taken at airport.
[2] Pressure not reduced to a 24-hour mean.
[3] Observations taken bihourly.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, January 1937*

Station	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	In.	In.	In.	°F.	°F.	°F.	°F.	°F.	°F.	In.	In.	In.
Cape Race, New Foundland	99	------	------	------	30.0	------	37.2	22.8	45.5	5.0	4.40	------	0.4
Sydney, Cape Breton Island	48	------	------	------	------	------	------	------	------	------	------	------	------
Halifax, Nova Scotia	88	------	------	------	------	------	------	------	------	------	------	------	------
Yarmouth, Nova Scotia	65	------	------	------	------	------	------	------	------	------	------	------	------
Charlottetown, Prince Edward Island	38	------	------	------	------	------	------	------	------	------	------	------	------
Chatham, New Brunswick	28	------	------	------	------	------	------	------	------	------	------	------	------
Father Point, Quebec	20	30.11	30.14	+0.16	15.1	+7.1	23.8	6.4	37.9	−8.0	2.82	−0.03	25.6
Quebec, Quebec	296	29.81	30.16	+.14	17.9	+8.8	26.2	9.7	47.0	−12.8	3.81	−.20	24.1
Doucet, Quebec	1,236	------	------	------	------	------	------	------	------	------	------	------	------
Montreal, Quebec	187	------	------	------	------	------	------	------	------	------	------	------	------
Ottawa, Ontario	236	29.92	30.21	+.18	22.1	+12.5	30.8	13.5	48.0	−8.0	3.03	+.04	6.9
Kingston, Ontario	285	29.87	30.20	+.15	29.0	+11.9	36.0	22.1	50.0	1.7	5.14	+1.69	6.5
Toronto, Ontario	379	29.75	30.18	+.13	31.2	+9.8	37.4	24.9	52.6	10.8	5.18	+2.26	2.5
Cochrane, Ontario	930	------	------	------	2.2	------	14.2	−9.8	32.2	−33.2	3.47	------	34.7
White River, Ontario	1,244	28.67	30.07	+.06	−2.3	−1.9	12.6	−17.3	32.8	−44.0	5.07	+3.38	50.7
London, Ontario	808	------	------	------	27.6	------	35.0	20.1	55.0	−2.6	6.27	------	4.8
Southampton, Ontario	656	29.39	30.13	+.10	26.6	+6.2	33.3	19.8	55.2	5.8	2.73	−1.32	7.6
Parry Sound, Ontario	688	29.41	30.14	+.13	24.0	+10.2	31.8	16.1	48.0	−6.0	4.16	+.08	25.9
Port Arthur, Ontario	644	29.36	30.13	+.06	1.1	+2.0	12.0	−9.8	28.5	−28.0	6.66	+5.84	66.6
Winnipeg, Manitoba	760	29.30	30.21	+.10	−12.9	−6.1	−3.7	−22.2	14.8	−37.2	1.02	+.14	10.2
Minnedosa, Manitoba	1,690	28.22	30.19	+.09	−12.5	−5.3	−3.4	−21.6	15.1	−37.3	.17	−.63	1.7
Le Pas, Manitoba	860	------	------	------	−21.0	------	−12.3	−29.8	7.0	−42.0	.80	------	8.0
Qu'Appelle, Saskatchewan	2,115	27.71	30.16	+.08	−13.3	−9.5	−3.4	−23.3	32.0	−39.0	1.18	+.68	11.8
Moose Jaw, Saskatchewan	1,759	------	------	------	−12.2	------	−2.1	−22.4	34.5	−39.0	.72	------	7.2
Swift Current, Saskatchewan	2,392	27.42	30.17	+.08	−9.6	−12.7	−.1	−19.1	34.0	−32.7	1.20	+.56	12.0

TABLE 3.—*Data furnished by the Canadian Meteorological Service, January 1937*—Continued

Station	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	In.	In.	In.	°F.	°F.	°F.	°F.	°F.	°F.	In.	In.	In.
Medicine Hat, Alberta	2,365	27.52	30.18	+.11	−5.7	−11.2	4.7	−16.1	36.6	−40.9	.58	+.01	5.8
Calgary, Alberta	3,540												
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.55	30.28	+.19	−17.4	−9.0	−5.0	−29.8	20.0	−49.0	.69	−.28	6.9
Battleford, Saskatchewan	1,592	28.35	30.26	+.18	−19.9	−14.0	−6.9	−33.0	37.0	−51.5	.61	+.21	6.1
Edmonton, Alberta	2,150	27.72	30.18	+.15	−3.7	−5.5	4.7	−12.1	38.0	−38.0	.93	+.25	9.3
Kamloops, British Columbia	1,262	28.88	30.26	+.30	5.8	−17.2	12.0	−.3	25.5	−21.0	3.68	+2.86	36.8
Victoria, British Columbia	230	29.82	30.08	+.11	31.2	−7.3	34.7	27.6	44.8	19.0	2.32	−3.07	12.1
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20				34.4		39.9	28.8	45.0	21.0	3.46		4.8
Prince Rupert, British Columbia	170				30.6		36.9	24.4	46.0	15.0	4.72		4.4
St. Georges, Bermuda	158		30.31	+.18	68.9	+6.2	74.0	63.8	79.5	59.5	1.08	−3.54	.0
LATE REPORTS FOR DECEMBER 1936													
Sydney, Cape Breton Island	48	30.08	30.13	+0.24	30.3	+2.1	37.6	23.0	56.0	10.0	7.94	+3.31	1.2
Halifax, Nova Scotia	88	29.93	30.04	+.08	30.9	+3.3	38.2	23.6	55.0	9.0	9.63	+4.51	T
Yarmouth, Nova Scotia	65	30.09	30.16	+.18	33.3	+2.6	41.5	25.0	52.0	10.0	7.39	+2.62	4.5
Charlottetown, Prince Edward Island	38	30.10	30.14	+.20	26.8	+2.5	34.4	19.3	50.0	8.0	6.25	+2.59	11.8
Chatham, New Brunswick	28	30.07	30.11	+.17	20.7	+3.7	30.6	10.9	51.0	−10.0	4.57	+1.35	4.6
Montreal, Quebec	187	30.01	30.23	+.20	22.8	+4.5	30.8	14.8	49.5	−1.3	3.17	−.48	15.9
Kingston, Ontario	285	29.88	30.21	+.17	27.4	+3.7	35.5	19.3	47.5	−6.0	3.58	+.34	10.7
Toronto, Ontario	379	29.76	30.19	+.14	31.5	+4.5	37.7	25.2	52.8	5.4	3.37	+4.8	7.7
White River, Ontario	1,244	28.67	30.04	+.07	13.4	+3.7	25.7	1.0	48.0	−31.0	2.71	+1.00	19.9
London, Ontario	808				29.0		36.3	21.8	52.4	−6.0	3.30		5.6
Southampton, Ontario	656	29.41	30.15	+.13	29.0	+2.3	35.6	22.4	56.2	−3.2	2.09	−1.89	9.4
Parry Sound, Ontario	688	29.42	30.15	+.14	24.9	+3.7	32.1	17.7	49.0	16.0	4.76	+.28	12.5
Port Arthur, Ontario	644	29.36	30.10	+.11	14.9	+1.7	24.6	5.2	42.0	−25.0	3.48	+2.61	21.8
Minnedosa, Manitoba	1,690	28.10	30.02	.00	8.1	+2.4	17.2	−.9	43.8	−31.5	1.07	+.45	10.7
Le Pas, Manitoba	860				−1.1		7.3	−9.6	30.0	−30.0	3.15		31.5
Moose Jaw, Saskatchewan	1,759				11.3		20.4	2.3	48.5	−33.2	.65		6.5
Swift Current, Saskatchewan	2,392	27.32	29.97	−.02	12.1	−3.9	20.8	3.4	49.2	34.0	.70	−.08	7.0
Prince Albert, Saskatchewan	1,450	28.39	30.06	+.05	2.1	−.7	11.8	−7.6	35.0	−39.0	1.41	+.67	14.1
Battleford, Saskatchewan	1,592	28.20	30.05	+.06	1.6	−3.8	12.3	−9.0	42.5	−46.0	1.52	+1.20	15.2
Edmonton, Alberta	2,150	27.57	29.98	+.05	9.2	−3.9	15.9	2.5	40.0	−25.0	.76	+.06	7.6
Kamloops, British Columbia	1,262	28.65	29.97	+.03	29.3	+.4	33.6	24.9	55.0	6.5	.63	−.15	6.0
Victoria, British Columbia	230	29.70	29.96	−.01	42.6	+1.4	46.1	39.1	53.2	28.8	8.35	+.37	.0
Prince Rupert, British Columbia	170				34.7		38.8	30.6	49.0	21.0	11.68		13.0

TABLE 4.—*Severe local storms, January 1937*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials. The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Sioux City, Iowa	1-2					Blizzard	From 10 p. m. of the 1st, to noon of the 2d, 8.5 inches of snow fell on a blanket 5.5 inches thick. Snowdrifts blocked highways. Only bus service open was that to Omaha on the Iowa side of the Missouri River.
Hoxie, Kans	2					do	
East Aurora to Westfield, N. Y.	2					Wind and snow	Telephone and power poles down; highway traffic delayed.
Livingston, Mont	3					Wind	Large radio tower at the Livingston Airport crashed, causing an unestimated amount of damage, putting the radio beam, used to guide pilots of airplanes throughout this section, out of commission.
Buffalo, N. Y.[1]	3					Wind and snow	Maximum velocity of 57 miles an hour recorded in the afternoon; 1 person injured.
Havre, Mont	3-4					Blizzard	Storm began 11 p. m. of the 3d and continued until late in the night of the 4th. At times during the second day in the afternoon blowing snow was so thick and fine that it greatly reduced visibility. Rural roads impassable, a number of teachers being unable to return to their schools.
Augusta, Mont., vicinity of	4	P. m.				do	
Charles City, Iowa	6					Glaze	All surfaces ice-coated; pavements and walks very slippery.
Rapid City, S. Dak	6-7					Wind and snow	Highways and railroad transportation interrupted by blinding snow, strong winds, and intense cold.
Springfield, Mo., and vicinity	6-9				$5,000	Sleet and glaze	Storm began evening of the 6th and with dense fog made traffic hazardous. The morning of the 7th, found streets, highways, and walks covered with ice ½ to ¾ inch thick. Damage to power lines and trees began when the ice-coating increased. Communication lines, within a radius of 100 miles of Springfield, down. Estimate given for local damage only.
Springfield, Ill., and vicinity	7					Glaze	2.41 inches of rain fell and froze causing all exposed objects to be ice-coated. Much damage to trees and wires.
Iowa	7	P. m.				Sleet and snow	Sleet turned to heavy snow in western Iowa in the early evening. At 9:30 p. m., 7 inches of new snow had fallen. Planes were grounded between Chicago, Ill., and Cheyenne, Wyo. Sleet totaled more than an inch at Des Moines and continued intermittently until midnight with the temperature at 3°. 5 persons injured.
Providence, R. I.	7			1		Rain and sleet	Numerous accidents in Providence and throughout Rhode Island because of icy sidewalks and highways.
El Paso, Tex	7			3	10,000	Wind	Damage to signs, roofs and plate-glass windows. 2 persons killed by falling masonry and another electrocuted; 2 persons injured.
Keokuk, Iowa	7-8					Sleet and glaze	Sleet covered the ground to the depth of about 1.5 inches. Glaze formed on all exposed objects from 7 p. m., of the 7th and continued until the rain ended on the 8th. Many trees badly damaged.

[1] From press reports.

TABLE 4.—*Severe local storms, January 1937*—Continued

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials. The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Topeka, Kans.	7-8					Sleet	An unprecedented fall of sleet, 2.6 inches, some remaining on the ground until the close of the month. Pavements and sidewalks slippery.
Wichita, Kans.	7-8					do	Thunder, lightning, and zero weather accompanied the sleet which fell to the depth of 2.5 inches. Several accidents reported.
Columbia, Mo., and vicinity	7-8					Glaze	This storm reported as the worst glaze storm ever known in this section. Homes without electric service for from 4 days to more than 2 weeks. Property damage not estimated. $40,000 loss to public utilities alone. Many old trees and much shrubbery ruined. For the second day, Hannibal, Bowling Green, Louisiana, and other northeastern Missouri cities were isolated from outside communication except for delayed-schedule train service. Other cities in central Missouri likewise isloated or had greatly impaired telephone and telegraph facilities. On the 9th, for the first time in 21 years, the Weather Bureau office at Columbia, Mo., was without connection with other weather stations throughout the country, the observer being unable to print the map for lack of information.
Texas, northeastern portion	7-12				$3,000,000	do	Icicles formed on the fire escape of the building occupied by the Dallas Weather Bureau office, about noon, Jan. 7, thawed 12:25 p. m., Jan. 12, which is the longest period for icicles to have remained on objects suspended in the air, in this vicinity since the regular Weather Bureau station was established. Ice on wires 1 to 2 inches thick near Athens and Tyler, Tex.
Arkansas, northwestern portion	8-9					Rain and sleet	This reported to be probably the worst ice storm in the history of this section of the State. Timber and shrubbery severely damaged. Power and communication lines broken.
Grand Rapids, Mich.	13	12:40-3:15 p. m.				Glaze	Streets and walks hazardous.
Cleveland, Ohio, and vicinity	13-14	P. m.			10,000	Gale	Several buildings wrecked; chimney blown down.
Cleveland, Ohio	14				25,000	Heavy rain	Streams overflowed; sewers inadequate in some sections; several manufacturing plants flooded.
Block Island, R. I.	17					Wind	Winds increased during afternoon and evening causing the New York boats to anchor in the bay until conditions were such that they could proceed to New York. Block Island was without boat service.
Milwaukee, Wis.	20					Glaze	Bus traffic to Chicago, Green Bay, and the Northwest was completely stopped.
Grand Rapids, Mich.	20-21					Sleet and glaze	Streets and walks extremely slippery. Thin film of snow in the evening of the 21st increased the hazard. Several minor injuries and accidents reported.
Harrisburg, Pa.	20-21					Glaze	Streets and walks dangerously slippery.
Rapid City, S. Dak., vicinity of	20-21					Wind and snow	Snow drifted causing obstruction to transportation.
Oklahoma City, Okla.	21	A. m.				Sleet	The severe intensity of the sleet made driving dangerous.
Springfield, Mo., and vicinity	21-22					do	2 inches of sleet covered the ground at 2 p. m., and changed to light, dry snow at 7:40 p. m., and by 3:30 p. m., on the 22d, approximately 2½ inches of sleet covered with 7½ inches of snow was on the ground. Traffic was greatly delayed.
Memphis, Tenn., and vicinity	22-23				100,000	Glaze	Traffic hazardous; damage to streets and bridges.
Arkansas	22-24					Rain and sleet	Freezing rain in connection with sleet was exceptionally heavy in the northern portion, the ground being coated with ice to the depth of 4 inches. Timber, shade trees and shrubbery severely damaged. Telegraph, telephone, and power lines down leaving some sections without lights and communication service from 2 to 3 days.
Cleveland, Ohio	24					Heavy rain	Streams overflowed; streets flooded in some sections; sewers being inadequate.
Norfolk, Va.	29				800	Wind	High winds caused unusually high tide, flooding the low-lying sections, tying up traffic for several hours. Damage to plate-glass windows, signs and awnings.
Wichita, Kans.	30			4		Mist and fog	Thin ice-coating formed on all objects; pavements dangerously slippery; several persons injured.
Rhode Island	31	P. m.		4		Rain and wind	Many persons injured in highway accidents because of low visibility.
Oregon [1]	Jan. 31-Feb. 1			5		Snow and rain	Main arteries of travel blocked by record storm. Travel by stage and private automobile impossible, except in limited sections where snow plows worked or where rain had fallen. All air line trips during day and night canceled. Telephone and telegraph lines down generally in the area south of Salem to Grants Pass and on the southwest Oregon coast. In Portland a marquee of a downtown hotel collapsed under weight of snow. Portland physicians marooned in own homes and residences of patients.

[1] From press reports.

U. S. GOVERNMENT PRINTING OFFICE: 1937

Chart I. Departure (°F.) of the Mean Temperature from the Normal, January 1937

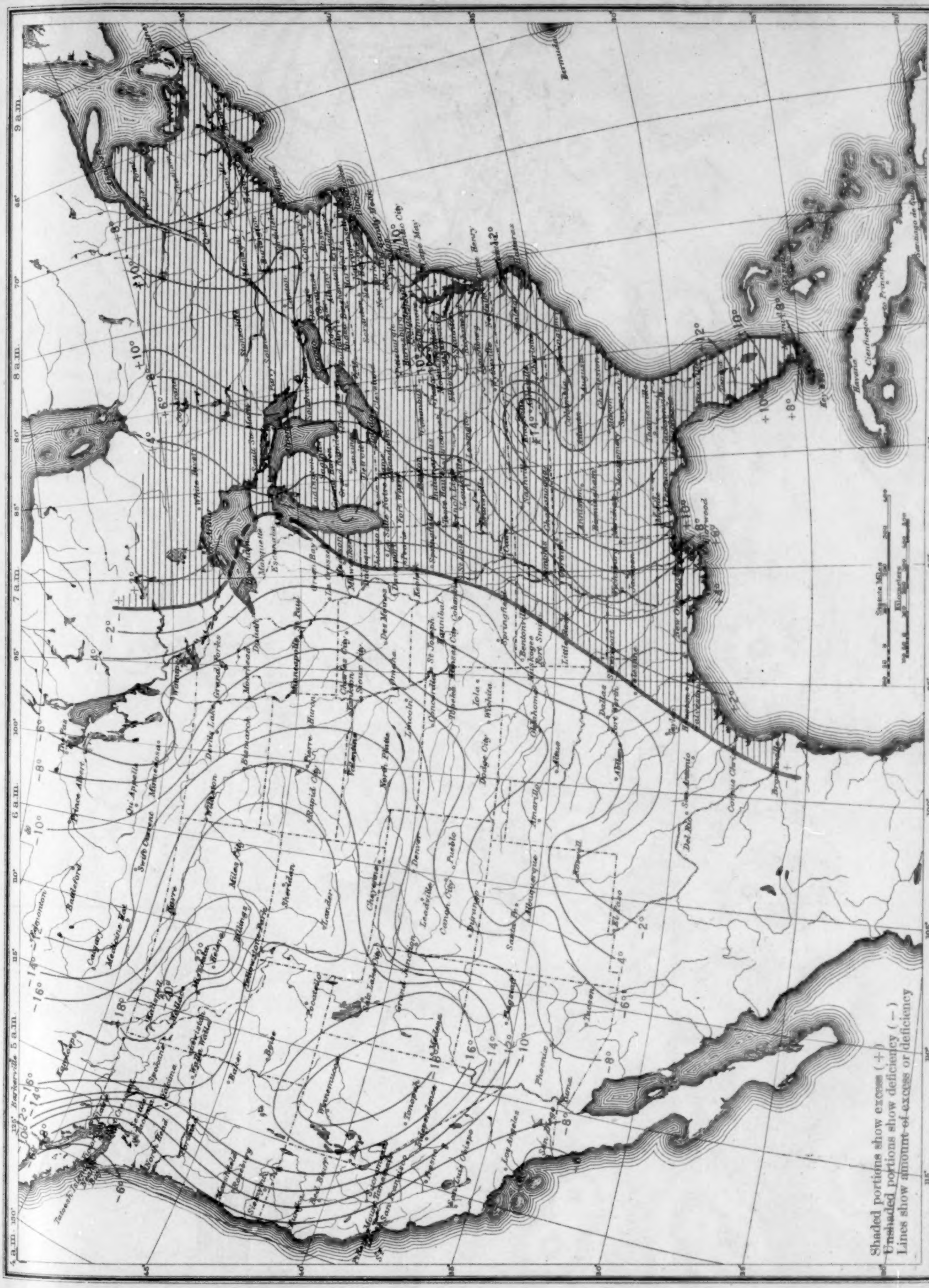
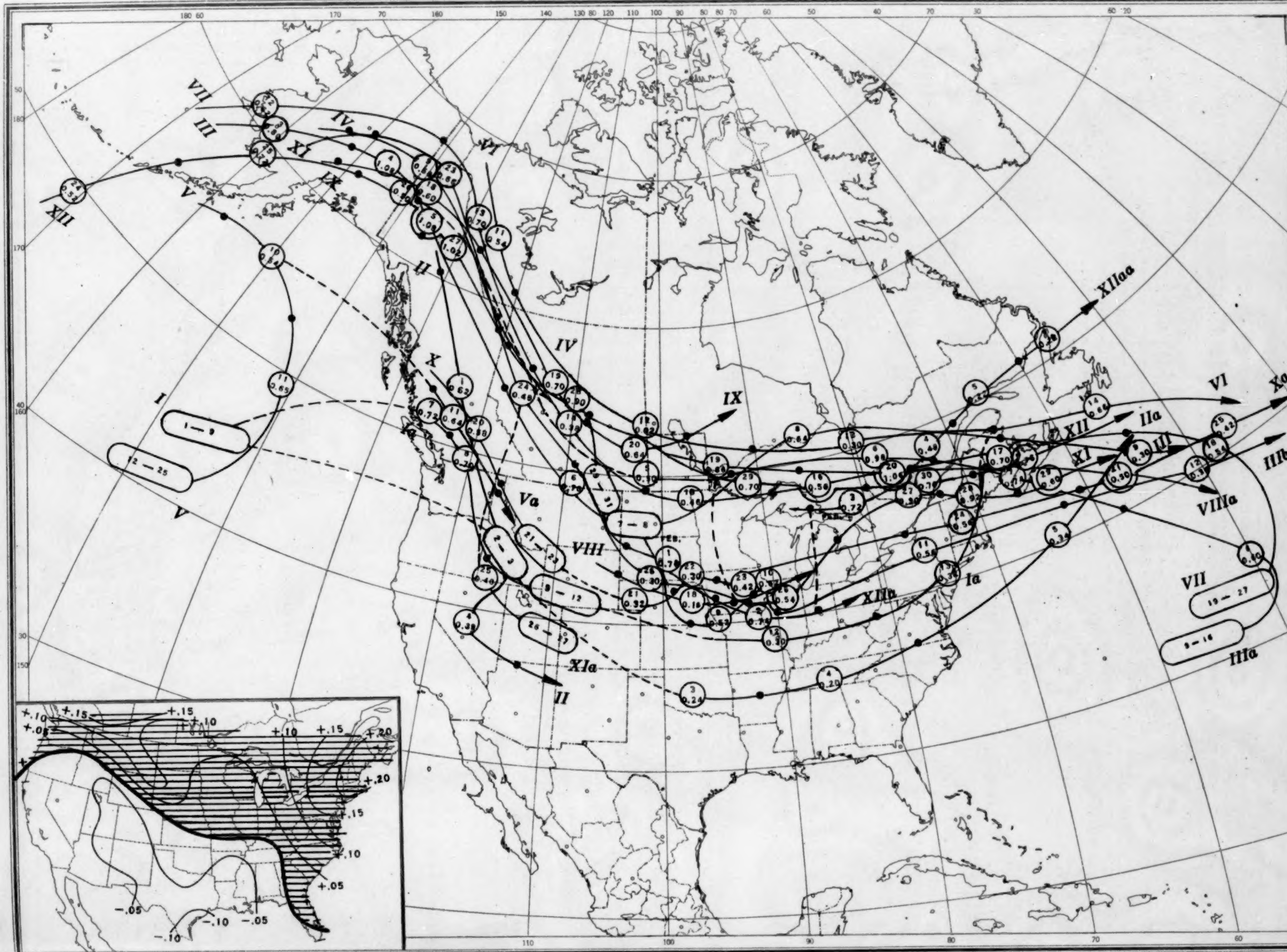


Chart II. Tracks of Centers of Anticyclones, January 1937. (Inset) Departure of Monthly Mean Pressure from Normal
(Plotted by W. P. Day)



Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, January 1937. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by W. P. Day)

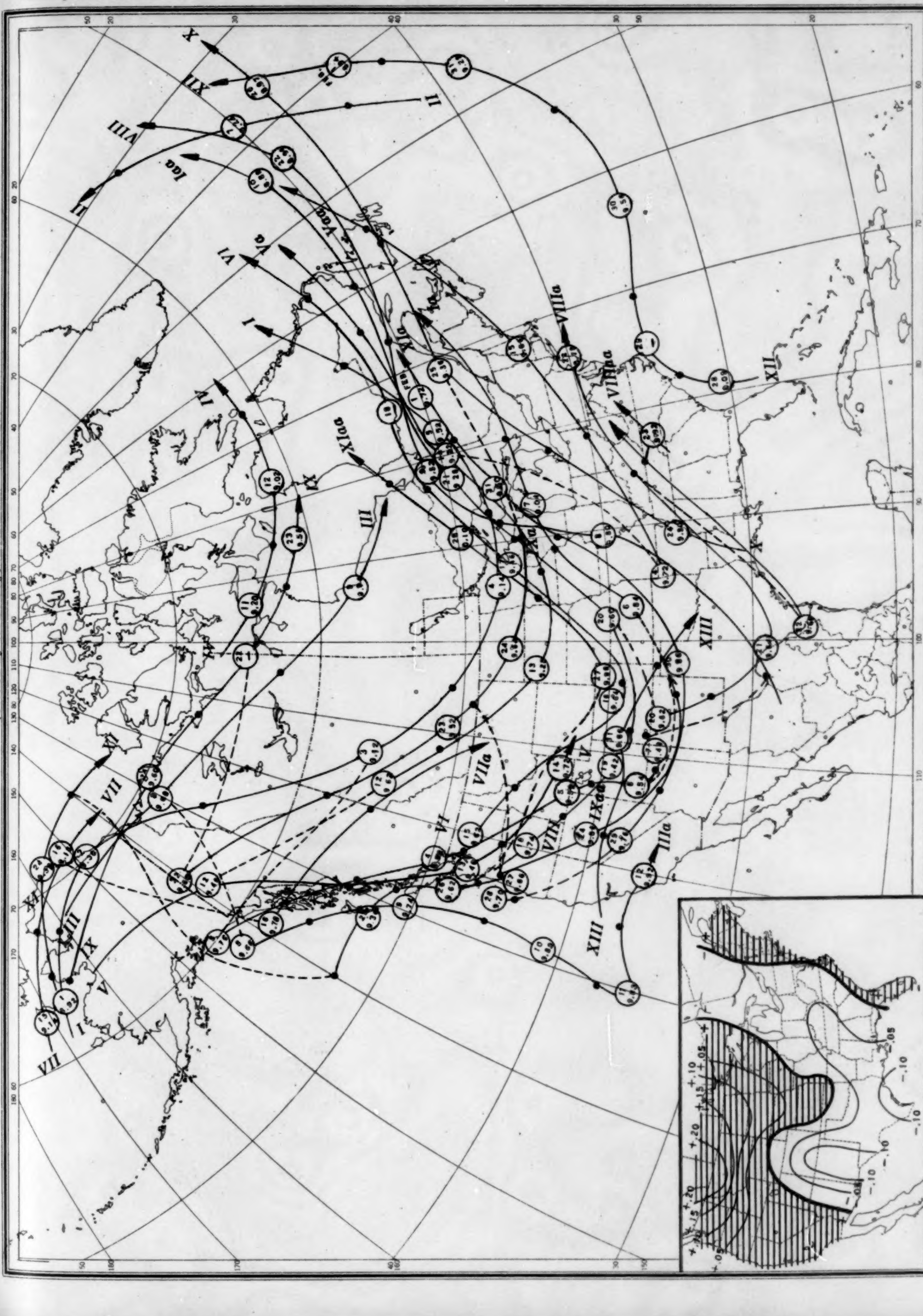


Chart III. Tracks of Centers of Cyclones, January 1937. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by W. P. Day)

Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, January 1937

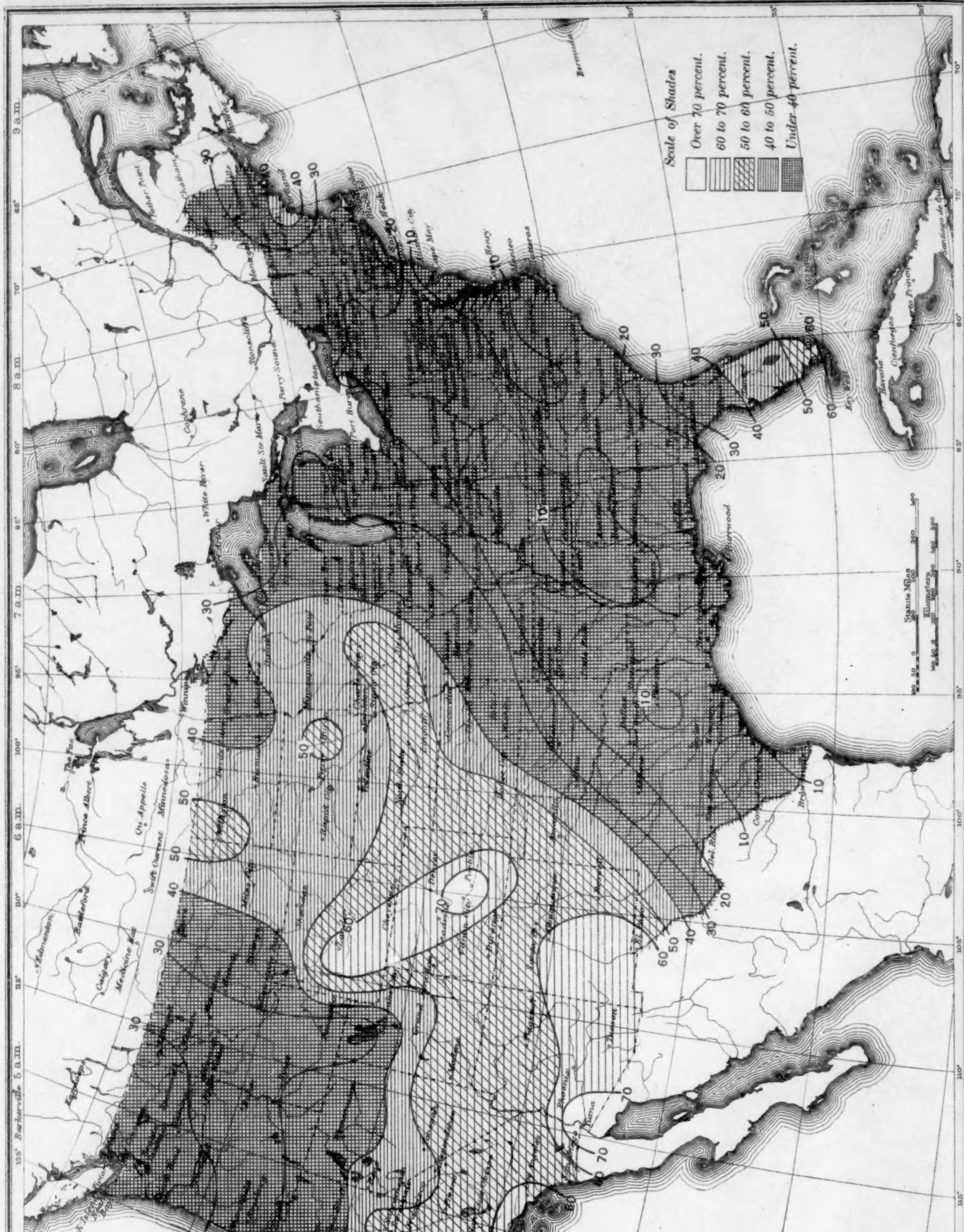


Chart V. Total Precipitation, Inches, January 1937. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, January 1937. (Inset) Departure of Precipitation from Normal

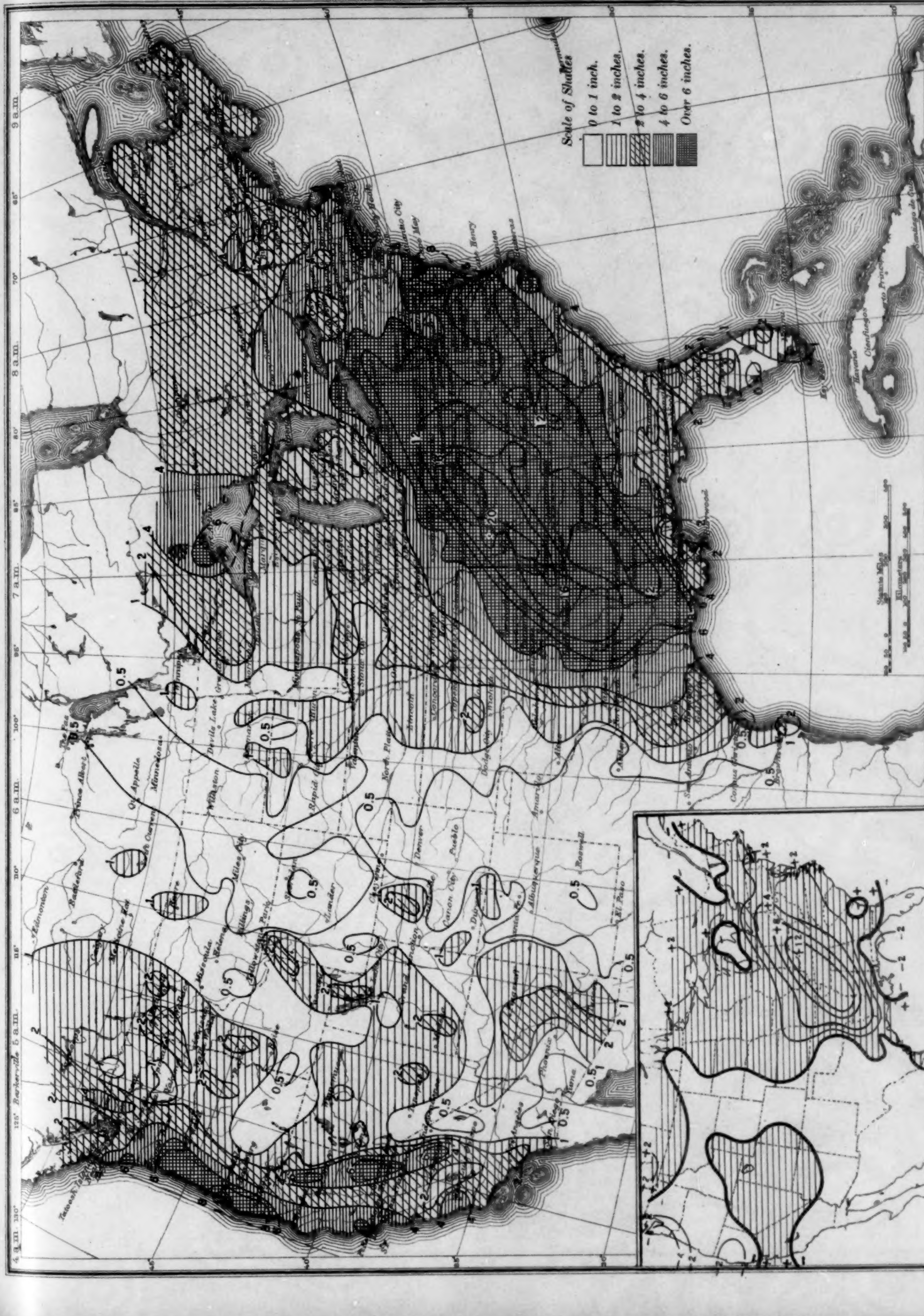


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, January 1937

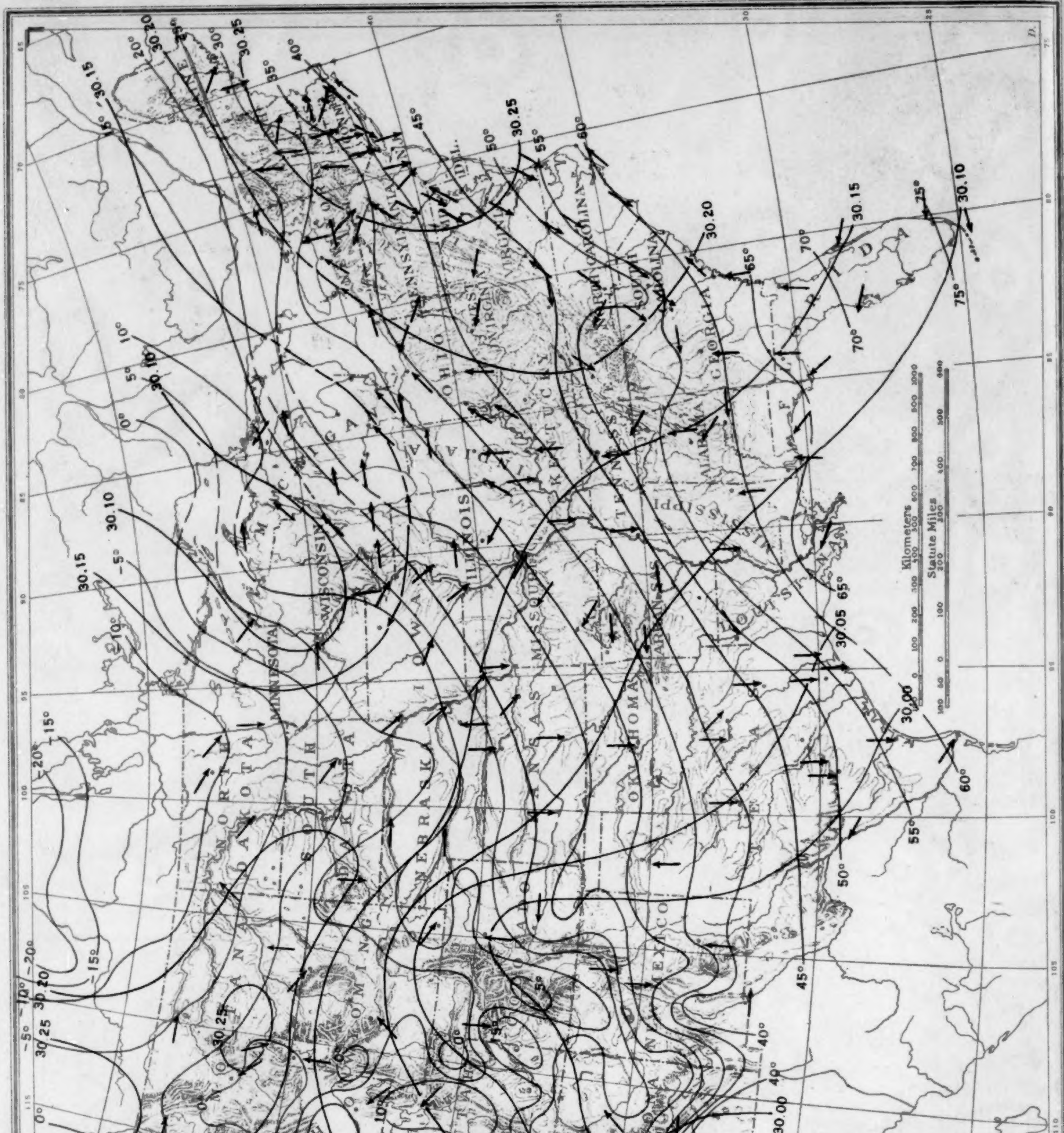


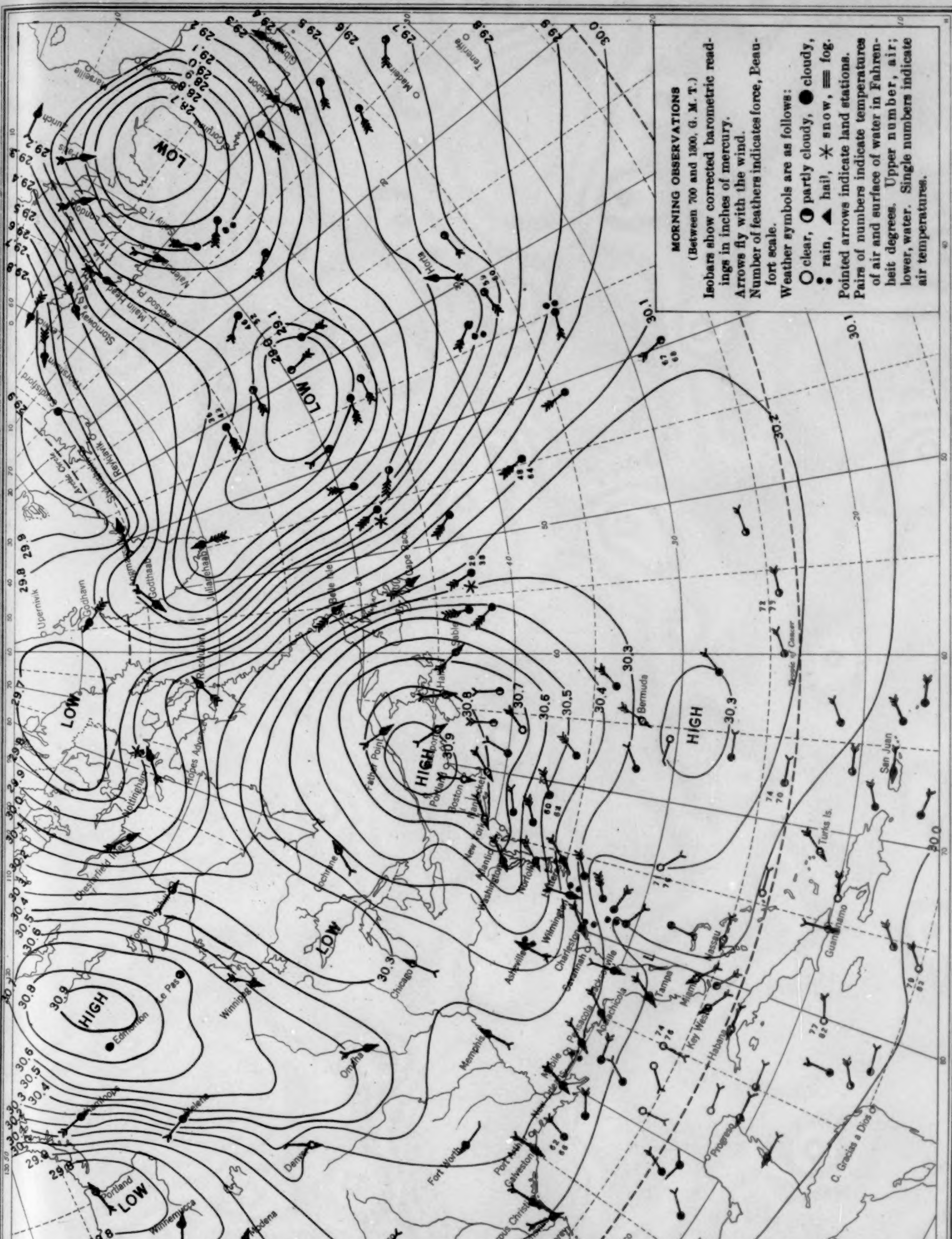
Chart VII. Wind Roses for Selected Stations, January 1937
(Plotted by W. W. Reed)

Chart VII. Wind Roses for Selected Stations, January 1937

(Plotted by W. W. Reed)

Chart VIII. Total Snowfall, Inches, January 1937. (Inset) Depth of Snow on Ground at 7:30 p.m., Monday, February 1, 1937

(Plotted from the Weather Bureau Northern Hemisphere Chart)



(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart X. Weather Map of North Atlantic Ocean, January 29, 1937

(Plotted from the Weather Bureau Northern Hemisphere Chart)